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# THE EASTERN HEMLOCK.[1]

(*Tsuga canadensis* (Linn.) Carr.)

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## INTRODUCTION.

Though excelled in most respects by other trees in the region of its growth, eastern hemlock is none the less a most important member of the remaining old-growth forests. Its lumber, once held nearly worthless, now serves many purposes for which pine was formerly demanded; its wood supplies more raw material for paper pulp than does any other in the United States except spruce, while the amount of its bark used for tanning exceeds that of all other native species combined. Compared with pine, hemlock has been lumbered for only a short time, but this exploitation, accompanied as it has often been by waste and fire, has already greatly reduced the supply of standing timber. If the present rate of cutting continues hemlock will before very long be as scarce as old-growth pine.

In spite of its present importance, hemlock is not a tree of promise for forest planting. White and red pine will yield better lumber in a much shorter time and on poorer soils, are less suceptible to decay, and are more easily grown. Spruce serves as well for the protection of watersheds and stream sources, and produces better pulpwood and lumber. Several other species produce fully as good tan bark or extract in a shorter time. Nevertheless hemlock will undoubtedly persist in the old-growth forests and natural second-growth in many regions, and its presence in these stands may be of decided benefit to them. For this reason it must be considered in forest management.

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[1] There are two species of hemlock in the eastern United States, but one—*Tsuga caroliniana* Engelm.—is restricted to the Southern Appalachians, and is of only local importance. This bulletin treats only of the other species—*Tsuga canadensis* (Linn.) Carr.

NOTE.—This bulletin describes the more important characteristics of hemlock, presents tables of its volume and rate of growth, and gives the chief facts regarding its utilization. Acknowledgment is due to Messrs. E. M. Griffith, State Forester of Wisconsin, and R. S. Kellogg, Secretary of the National Lumber Manufacturers Association, for assistance rendered in the field study and in the course of preparation of this bulletin.

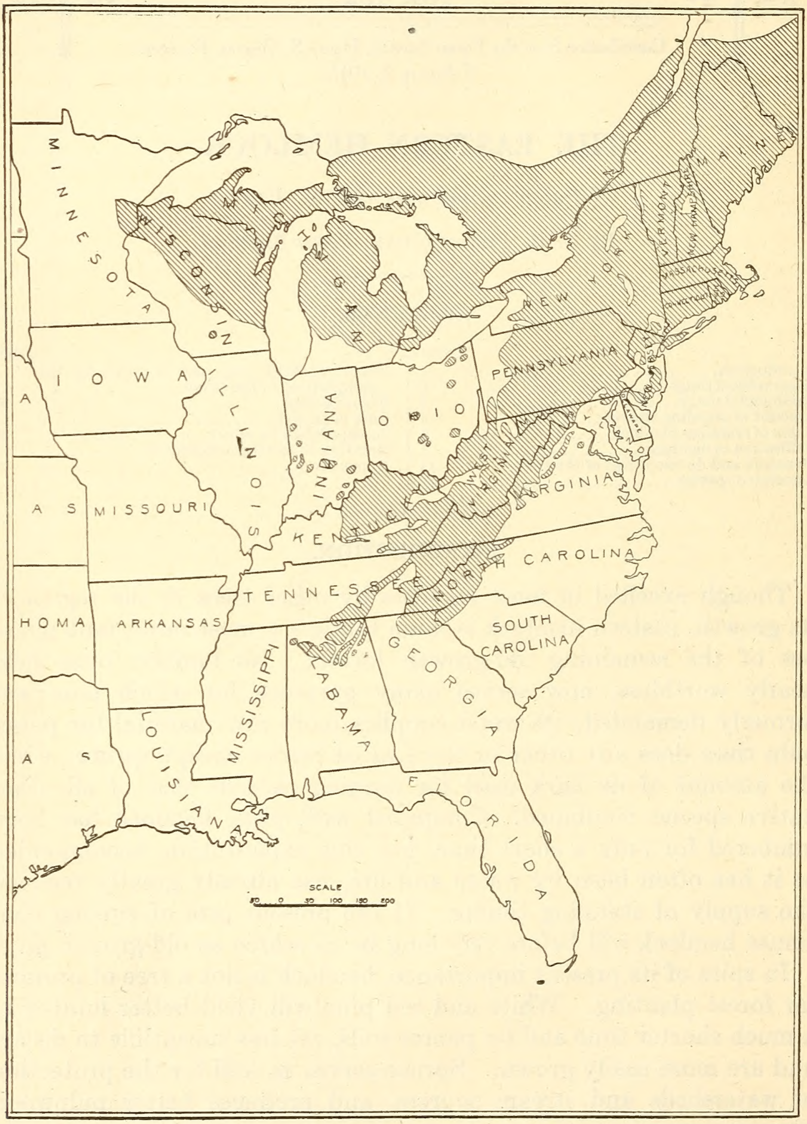

FIG. 1.—Botanical distribution of hemlock.

## GEOGRAPHICAL RANGE.

Hemlock finds its home in the white pine region of eastern North America. This also is the region inhabited by the characteristic beech-birch-maple forest—the "northern hardwoods"—of which hemlock is often a conspicuous member. The tree's northern limit corresponds roughly with the forty-seventh parallel of latitude, from Nova Scotia to east central Minnesota (Carlton, St. Louis, and Aitkin Counties, and the St. Croix River), whence it extends south to central Wisconsin, southern Indiana (Floyd County), central Ohio, and northwestern Delaware. It is important in the mountainous portions of New England, New York, and Pennsylvania, and extends along the Appalachian Mountains, through western Maryland, eastern West Virginia, southwestern Virginia, eastern Kentucky and Tennessee, and western North and South Carolina, into northern Georgia and Alabama. It grows neither so far north nor so high in the mountains as the eastern spruces and firs,[1] and reaches its greatest size in the coves of the mountains of western North Carolina and eastern Tennessee.

## COMMERCIAL RANGE.

About two-thirds of the total cut of eastern hemlock lumber comes from Wisconsin, Michigan, and Pennsylvania, in the order named, with West Virginia, New York, and Maine following. The other States within its range aggregate about 11 per cent. The shifting of the relative importance of different States in hemlock production within recent years is shown in Table 1, based on data collected by the Census Bureau and the Forest Service.

TABLE 1.—*Hemlock lumber cut in different States, in per cent of the total cut of hemlock, and rank of States in order of production.*

[From United States Census reports for 1899, 1904, and 1906–1912.]

| State. | 1913 | | 1911 | | 1909 | | 1907 | | 1899 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Proportion of total cut. | Rank. | Proportion of total cut. | Rank. | Proportion of total cut. | Rank. | Proportion of total cut. | Rank. | Proportion of total cut. | Rank. |
| | *Per cent.* | | *Per cent.* | | *Per cent.* | | *Per cent.* | | *Per cent.* | |
| United States | 100 | ...... | 100 | ...... | 100 | ...... | 100 | ...... | 100 | ...... |
| Wisconsin | 28.7 | 1 | 26.6 | 1 | 23.2 | 1 | 23.3 | 2 | 11.7 | 3 |
| Michigan | 19.0 | 2 | 21.8 | 2 | 20.1 | 3 | 20.4 | 3 | 24.6 | 2 |
| Pennsylvania | 14.2 | 3 | 18.2 | 3 | 22.5 | 2 | 25.2 | 1 | 45.6 | 1 |
| West Virginia | 8.9 | 4 | 10.3 | 4 | 9.2 | 4 | 8.0 | 4 | 2.5 | 5 |
| New York | 5.3 | 5 | 5.0 | 5 | 5.3 | 5 | 6.1 | 5 | 8.9 | 4 |
| Maine | 3.1 | 6 | 3.3 | 6 | 3.6 | 6 | 3.6 | 6 | 2.5 | 6 |
| Tennessee | 1.8 | 7 | 1.4 | 9 | 1.2 | 11 | 1.2 | 9 | ...... | 18 |
| North Carolina | 1.6 | 8 | ...... | ...... | 1.3 | 10 | .9 | 11 | ...... | 16 |
| Vermont | 1.3 | 9 | 1.5 | 8 | 2.0 | 8 | 2.2 | 8 | 1.2 | 8 |
| New Hampshire | 1.3 | 10 | 1.5 | 7 | 2.2 | 7 | 2.6 | 7 | 1.3 | 7 |
| Virginia | ...... | ...... | 1.2 | 10 | 1.4 | 9 | 1.1 | 10 | ...... | 15 |
| Massachusetts | ...... | ...... | 1.0 | 11 | .8 | 13 | .8 | 13 | .4 | 10 |
| Kentucky | ...... | ...... | ...... | ...... | .9 | 12 | .8 | 12 | .1 | 12 |
| Maryland | ...... | ...... | ...... | ...... | .7 | 14 | .7 | 14 | .6 | 9 |
| States producing western hemlock | 12.2 | ...... | 7.0 | ...... | 4.2 | ...... | 2.1 | ...... | .02 | ...... |
| All other States | 2.6 | ...... | 1.2 | ...... | 1.4 | ...... | 1.0 | ...... | .58 | ...... |

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[1] Hemlock is not found where the average temperature during the four growing months is less than 55° F., and but seldom where the average is below 58°. (For. Quart., Vol. XI, No. 1, pp. 64–66, "Northern Limits of East Canadian Trees in Relation to the Climate," by H. R. Christie.)

## AMOUNT OF STANDING TIMBER.

Reliable estimates of the amount of standing hemlock are very difficult to obtain, because of the widely varying proportion which the tree forms of the mixed forests in which is usually grows. For this reason past estimates have been greatly at variance with one another. Thus the total stand was estimated to be 20,165 million board feet in 1880 by C. S. Sargent; 56,571 million board feet in 1903 by R. A. Long; 100 billion board feet in 1905 by the American Lumberman; and 75 billion in 1909 by R. S. Kellogg. In 1880 Sargent estimated the amounts of standing hemlock in Pennsylvania, New York, and New Hampshire to be 4½ billion, 3 billion, and 165 million board feet, respectively. The stand in Pennsylvania was estimated to be 5 billion board feet in 1896 by Dr. B. E. Fernow, and 10 billion board feet in 1907 by J. E. Defebaugh.

By far the most careful estimates are those for the Lake States prepared by the Bureau of Corporations in 1910.[1] According to these the amount of standing hemlock in the Lake States is 26.6 billion board feet, of which Michigan has 15 billion and Wisconsin 11.6 billion. Hemlock comprises 34.6 per cent of all the standing timber in both States—31.5 per cent of that in Michigan, and 39.7 per cent of that in Wisconsin. Compared with these estimates the production of hemlock lumber in Michigan and Wisconsin during 1909 represented 4.1 per cent and 6.1 per cent, respectively, of the total stand. For all species combined this relation was 4 per cent and 6.9 per cent, respectively, which makes it evident that the cutting of hemlock proceeds at a rate very close to the average for all species—more rapid than for hardwoods and much slower than for pine.

Hemlock may form a very small or a very large proportion of the forest, while between these extremes are all gradations. One of the largest remaining stands of hemlock in the Lake States is on the Menominee Indian Reservation. The total stand of all species was estimated about 1910 to contain 1,750,000,000 board feet, running 15,000 per acre, of which more than 40 per cent, or 6,000 per acre, was hemlock, the timber varying in size from 6 to 33 logs to the thousand board feet.

In 1905 and 1906 the Forest Service[2] secured from local timber operators estimates of the amount of standing timber in each county of the Southern Appalachian region. The estimate of standing hemlock was as follows:

|  | Board feet. |  | Board feet. |
|---|---|---|---|
| Georgia | 205,000,000 | Tennessee | 1,387,000,000 |
| Kentucky | 452,000,000 | Virginia | 505,000,000 |
| Maryland | 60,000,000 | West Virginia | 3,550,000,000 |
| North Carolina | 668,000,000 |  |  |
| South Carolina | 93,000,000 | Total | 6,920,000,000 |

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[1] Report on the Lumber Industry, Part I: Standing Timber. Washington, Government Printing Office, 1913.

[2] Study of Forest Conditions of the Southern Appalachians, under the direction of Walter Mulford.

According to this, hemlock is the most abundant conifer in the mountainous regions south of Pennsylvania. Its nearest competitor is spruce, with a total of less than 3,000,000,000 board feet. In Maryland nearly all the hemlock is in Garrett County. In West Virginia over 80 per cent is in the high mountains of Pocahontas, Randolph, Tucker, and Webster Counties, and the western part of Grant and Pendleton Counties, where it covers large areas just below the spruce belt. Eighty per cent of the hemlock in Virginia lies west of New River, and 50 per cent is in Grayson, Smyth, and Washington Counties. Here, also, the heaviest bodies lie below the spruce in the "spruce and hemlock region." Farther south hemlock forms a smaller proportion of the stand, though it is often very dense in the coves and lower slopes. It becomes less abundant as the mountains become lower, and fails altogether where the foothills and plains begin.

## VALUE OF STANDING HEMLOCK.

The stumpage value of hemlock is generally lower than that of the other important eastern trees. White and red pine, white ash, basswood, elm, oak, and hickory all considerably exceed it. Birch and maple, which average a little less in value than hemlock in the northeast, exceed it in the Lake States and Southern Appalachians. Beech is perhaps the only important species in the Lake States whose average stumpage value is not greater than that of hemlock, while in the South hemlock is the least valuable of all the species. Table 6 gives the relative stumpage values of hemlock and associated species in 1912, based on a large number of reports of timber sales received by the Forest Service.

TABLE 6.—*Comparative stumpage values per thousand board feet of hemlock and associated species, in 1912.*[1]

| Species. | North-eastern States. | Lake States. | Southern States. |
|---|---|---|---|
| Hemlock | $6.28 | $3.78 | $2.62 |
| White pine | 8.44 | 10.39 | 3.91 |
| Ash | 9.03 | 5.82 | 6.16 |
| Basswood | 8.40 | 6.30 | 4.92 |
| Elm | 6.71 | 5.87 | 3.41 |
| Maple | 5.98 | 4.58 | 3.45 |
| Birch | 5.61 | 4.85 | 3.33 |
| Beech | 4.38 | 3.67 | 2.86 |

[1] From the reports of sales collected by the Forest Service, Office of Industrial Investigations. The States included under the headings of "Northeastern States," "Lake States," and "Southern States" are those given in Table 7.

Stumpage values are derived by deducting all logging, transporting, and manufacturing costs from the value of the lumber or other salable product. Wide ranges in stumpage value due to differences in accessibility may prevail within the bounds of a single State. As a rule, however, the stumpage value of most of the old-growth timber in a region is uniform enough to justify comparison with other regions. Table 7 gives such a comparison of average stumpage values of hemlock in 1889, 1899, 1907, and 1912, within the States where it is commercially important.

TABLE 7.—*Stumpage values per thousand board feet of hemlock in different States, for 1912,[1] 1907,[1] 1899, and 1889.*

| State. | 1912 | | 1907 | | 1899 | 1889 |
|---|---|---|---|---|---|---|
| | Average values (sales). | Reports. | Average values (estimates). | Reports. | Average values (estimates). | Average values (estimates). |
| Northeastern group: | | | | | | |
| Maine | $4.72 | 30 | $4.48 | 33 | $2.52 | $1.63 |
| New Hampshire | 5.57 | 10 | 5.22 | 17 | 3.19 | .......... |
| Vermont | 5.40 | 5 | 4.03 | 32 | 2.01 | .......... |
| Massachusetts | 6.44 | 9 | 6.10 | 24 | .......... | .......... |
| New York | 7.46 | 29 | 5.48 | 33 | 2.98 | .......... |
| Pennsylvania | 7.35 | 21 | 7.38 | 62 | 2.75 | 1.45 |
| Average (weighted) | 6.28 | .......... | 5.72 | .......... | .......... | .......... |
| Lake States: | | | | | | |
| Michigan | 5.07 | 14 | 4.22 | 85 | 2.25 | 1.05 |
| Wisconsin | 3.21 | 32 | 3.31 | 63 | 2.16 | .96 |
| Average (weighted) | 3.78 | .......... | 3.83 | .......... | .......... | .......... |
| Southern States: | | | | | | |
| Maryland | [2] 4.25 | [2] 4 | 3.88 | 4 | .......... | 2.50 |
| Virginia | [2] 3.17 | [2] 3 | 2.98 | 13 | .......... | .......... |
| West Virginia | 6.00 | 1 | 3.26 | 45 | 2.19 | .......... |
| Kentucky | 2.50 | 2 | 2.14 | 9 | .......... | .......... |
| Tennessee | 2.50 | 3 | 2.07 | 11 | .......... | .......... |
| North Carolina | 2.17 | 6 | 1.43 | 7 | .......... | .......... |
| Average (weighted) | 3.05 | .......... | 2.84 | .......... | .......... | .......... |

The table shows that recently the rate of increase in value of hemlock has fallen off, at least in the Northeastern and Lake States. In Pennsylvania, for example, the stumpage value increased more than fivefold between 1889 and 1907, but during the next five years there was practically no increase. In 1889 hemlock was as yet practically unmerchantable in many parts of its range, and its cheapness and low taxable value assured large profits. At present, however, the increase in stumpage value is hardly rapid enough to yield a large profit, while taxes, insurance, and other annual charges often add substantially to the cost. To yield a return of 6 per cent compound interest it would be necessary for the stumpage value to double at least every 10 years. This, of course, applies only to old stands in which growth is very slow or is entirely offset by decay. In young, thirfty stands there is an increase in the amount of stumpage which may make the investment profitable without a great increase in stumpage value.

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[1] The figures for 1912 and 1907 are averages of reports collected by the Forest Service. For 1912, reports of both estimates and sales were collected. The averaged estimates (not shown for 1912) were slightly higher for almost every State than the averaged sales.

[2] Estimates.

## UTILIZATION OF HEMLOCK.

Though hemlock first came into use because of the growing scarcity and increasing value of better trees, it can no longer be considered merely a substitute for these species. In the three large industries to which it contributes—lumber, pulp, and bark—it has become practically indispensable.

### LUMBER.

Small quantities of hemlock lumber were produced locally in the northeast during the early days, but not until the bulk of the pine had gone was it able to find a wider market. As long as the best grades of pine lumber could be had for very little more than the cost of production, hemlock could not be disposed of profitably. As late as 1880 hemlock lumber of the first quality had so little market value in New York and Pennsylvania that it could be shipped only at a loss, and was often sold at the mill to local consumers for as little as $4.50 per thousand board feet. Hemlock logs, cut and peeled for tanbark, could not be hauled with profit even for short distances, and large numbers of them had to be left in the woods to rot. When peeled and well dried, hemlock logs float nearly as well as pine, and because of their slipperiness are useful, when driven with pine and spruce logs in breaking jams. Peeled logs check badly in drying, however, and necessitate heavy and wasteful slabbing. In spite of this drawback hemlock formed an average of about 10 per cent of all lumber on the Penobscot River in Maine from 1851 to 1895, with a steady rise of from 7 per cent in 1851 to 15.3 per cent in 1895.[1]

During the last five years hemlock has ranked fifth in importance among the lumber trees of the United States, being exceeded only by yellow pine, Douglas fir, white pine, and oak. Table 2 shows the annual production of hemlock lumber during recent years, and its proportion in the total annual lumber production.

TABLE 2.—*Hemlock*[2] *lumber production during recent years, from census reports.*

| Year. | Annual cut. | Proportion of total lumber cut. | Year. | Annual cut. | Proportion of total lumber cut. |
|---|---|---|---|---|---|
| | *Thousand board feet.* | *Per cent.* | | *Thousand board feet.* | *Per cent.* |
| 1899 | 3,420,673 | 9.9 | 1909 | 3,051,399 | 6.9 |
| 1904 | 3,268,787 | 9.6 | 1910 | 2,836,129 | 7.1 |
| 1906 | 3,537,329 | 9.8 | 1911 | 2,555,308 | 6.9 |
| 1907 | 3,373,016 | 8.4 | 1912 | 2,426,554 | 6.2 |
| 1908 | 2,530,843 | 7.6 | 1913 | 2,319,982 | 6.0 |

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[1] From statistics contained in the Third Annual Report of the Forest Commission of the State of Maine, 1896, Appendix, p. 7.

[2] Including western hemlock, an entirely distinct timber tree, which increased from 0.02 per cent of all hemlock cut in 1899 to over 12 per cent in 1913.

As the higher grades of pine grew scarce and expensive, hemlock acquired a modest value of its own as a competitor with the successively lower grades of pine which were being introduced. Only the best hemlock was at first put on the market, but afterward lower grades came in for box manufacture and other purposes for which high-grade lumber was not required.

The production of only the best grade of hemlock necessarily involved a great deal of waste both in logging and sawing. Partially defective logs were culled out in the woods, because the lumber they contained would not pay for their removal. Hemlock, when mature, is commonly wind shaken and rotten at the butt, and branchy and tapering at the top, so the amount thus left was naturally very large. Many trees which contained some sound lumber were left standing. In the mill, peeled logs had to be heavily slabbed to remove season checks, and much of the heartwood might be unsalable because of knots and shakes. Many of the slabs and edgings were made into laths, but far more were burned. As lower grades of lumber became salable there was less waste; trees were cut farther into the top and shorter butts were taken, while slabs and edgings were sold to pulp mills. In some parts of the country the broken logs and tops left after logging are now cut into bolts and used for pulp. Means of utilizing waste are rapidly increasing, and the present problem is, which of these will pay best?

Though inferior to yellow pine and Douglas fir where great strength is required, hemlock lumber makes good building material and is said to give greater strength and firmness than white pine. It is well adapted for frames, sheathing, roofing, floor lining, and other construction purposes. It is softer and lighter than southern pine or Douglas fir, but holds nails as well. As drop siding it makes an excellent outside finish for barns and houses, if kept well painted. The best grades make attractive inside finish wherever a soft wood is appropriate.

The durability of the wood depends very largely upon the nature of its use. In contact with the soil it is very perishable, and is not well adapted for ground sills unless treated with a preservative. If kept in a dry place, however, it is extremely durable. Even as outside covering it will give good service if placed so that it dries out rapidly and thoroughly after being wet. There are instances of hemlock barns which still stand after 50 or more years' use. Shaved hemlock shingles, if of good, straight-grained wood and used on a moderately steep roof, are practically as durable as white pine shingles. An important defect of hemlock for such uses is its liability to check and split when exposed to the sun. Hemlock laths are said to make a firmer and better wall than pine, though harder to nail than either the latter or basswood.

Table 3 gives the average mill-run value per thousand board feet of hemlock lumber in different States for years for which census figures are available.

**Table** 3.—*Average value per thousand board feet of hemlock lumber, by years and States.*

| State. | Value of lumber per 1,000 board feet. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1912 | 1911 | 1910 | 1909 | 1908 | 1907 | 1906 | 1904 | 1899 |
| Northeastern group: | | | | | | | | | |
| Maine | $14.53 | $14.64 | $15.87 | $14.03 | $13.75 | $15.37 | $14.76 | $11.66 | $10.83 |
| New Hampshire | 15.08 | 14.89 | 14.99 | 15.02 | 13.98 | 15.49 | 14.85 | 11.72 | 10.70 |
| Vermont | 15.59 | 14.65 | 14.96 | 14.38 | 14.95 | 16.04 | 16.51 | 12.54 | 10.19 |
| Massachusetts | ........ | 16.51 | 16.59 | 15.59 | 13.39 | 15.84 | 14.88 | 13.28 | 11.84 |
| New York | 15.98 | 15.50 | 16.68 | 16.70 | 15.00 | 20.00 | 19.00 | 13.96 | 11.10 |
| Pennsylvania | 15.41 | 15.54 | 17.08 | 17.56 | 16.29 | 16.42 | 17.16 | 12.65 | 10.46 |
| Lake group: | | | | | | | | | |
| Michigan | 13.19 | 12.44 | 12.51 | 11.86 | 12.02 | 14.79 | 13.40 | 11.22 | 9.00 |
| Wisconsin | 13.00 | 13.03 | 12.25 | 12.06 | 12.34 | 14.60 | 14.43 | 11.07 | 9.37 |
| Southern group: | | | | | | | | | |
| Maryland | ........ | 14.33 | 14.94 | 12.97 | 14.53 | 16.63 | 15.69 | 12.98 | 7.98 |
| Virginia | ........ | 13.75 | 11.25 | 13.02 | 12.71 | 13.86 | 14.49 | 13.51 | 9.95 |
| West Virginia | 14.64 | 14.66 | 14.69 | 14.81 | 13.68 | 15.56 | 16.12 | 11.52 | 8.29 |
| Kentucky | ........ | 12.36 | 12.27 | 13.31 | 13.02 | 14.65 | 12.64 | 11.23 | 9.05 |
| Tennessee | ........ | 11.89 | 10.57 | 13.64 | 11.76 | 13.72 | 13.99 | 11.85 | 8.97 |
| North Carolina | ........ | 11.08 | 9.73 | 11.61 | 12.07 | 12.29 | 13.14 | 9.51 | 9.87 |
| Average | ........ | 13.59 | 13.85 | 13.95 | 13.65 | 15.53 | 15.31 | 11.91 | 9.98 |

From table 3 it will be seen that the value of hemlock lumber has fluctuated from year to year, both locally and for the country as a whole. The price was highest in 1907, and the effect of this upon stumpage values during the subsequent years is shown elsewhere in this bulletin. There are, of course, local deviations from the average values given for a State. In central Wisconsin, for example, an average price of about $15.40 per thousand board feet, mill run, prevailed in December, 1912. Apportioned by grades this amounted to $17.50 per thousand for No. 1, $15.50 for No. 2, and $10.50 for No. 3 lumber. During 1911 average prices of $15.40, $12.65, and $7.44 per thousand, respectively, were received for the same grades by one large firm in the same region. Compared with these values the prices paid for hemlock logs are high. Prices paid by operators at Wausau, Wis., are about as follows:

| Length of logs. | Winter of— | | |
|---|---|---|---|
| | 1912–13 | 1911–12 | 1910–11 |
| *Feet.* | | | |
| 12 to 14 | $9.50 | $7.50 | $8.00 |
| 16 to 16 | 10.00 | 8.00 | 8.50 |
| 18 to 20 | 10.50 | 8.50 | 9.00 |
| 22 to 24 | 11.00 | 9.00 | 9.50 |

The logs were scaled by the Scribner "Decimal C." rule.

## PULP.

In 1905 hemlock formed 11.8 per cent of all the wood used for pulp. In 1906 and 1907 it supplied 14 per cent of the total amount; in 1908, 17 per cent; in 1909, 14 per cent; and in 1910, 15 per cent. During the latter year its consumption was 50 per cent greater than in 1905.

Hemlock pulp is used for news, wrapping, and other cheap grades of paper, and is manufactured chiefly by the sulphite process. In this process the wood is first chipped and then cooked in a solution of calcium sulphite, which frees the fibers by dissolving the substances that unite them. The dissolved substances comprise about half the original weight of the dry wood, without bark. Hemlock also furnishes a small amount of ground wood pulp, but the great bulk of this is spruce. Ground wood is inferior to chemical pulp, since the fibers become broken in grinding, while the pulp contains the useless constituents which are dissolved out in the chemical process. As a result it is mealy and less interlaceable, especially in the case of hemlock, the fibers of which are shorter than those of spruce. In spite of this, a very serviceable grade of news paper can be made from hemlock pulp, 75 per cent ground and 25 per cent sulphite, with almost the strength, finish, and appearance of that made chiefly of spruce.[1]

Since the value per ton of ground wood is only about $15, as compared with $47 for sulphite pulp, the former is used as the basis for news and other cheap grades of paper, to which a small amount[2] of sulphite pulp is added for strength. Spruce once furnished practically all of both kinds of pulp, and still supplies 90 per cent of the mechanical pulp. Its increasing cost has brought about the use of cheaper woods in the sulphite process, during which so much of the volume is lost. Spruce now supplies less than 60 per cent of the sulphite pulp, while hemlock supplies about 25 per cent. The proportions of hemlock manufactured by the various processes for the six years from 1905 to 1910, inclusive, were—

| | Per cent. |
|---|---|
| Sulphite process | 94. 75 |
| Mechanical process | 4. 5 |
| Soda process | . 7 |
| Sulphate process | . 05 |
| | 100. 00 |

Hemlock pulpwood is marketed both as cordwood and in the log. In Wisconsin pieces 8 inches and over at the small end are ordinarily cut in log lengths and sold by the thousand board feet, 1,000 board feet usually being considered equivalent to 2 cords. Pieces less than 8 inches at the small end are sold by the "gross cord," or cord containing 128 cubic feet of stacked (not solid) wood, with the bark on. Unlike most cordwood, however, the pieces are not cut in 4-foot lengths, but usually in lengths of 8 feet, 12 feet, etc., according to the demands of the mill to which they are sold. Pieces less than 4 inches at the small end are rarely accepted. About 65 per cent of the wood is sold with the bark on, 33 per cent peeled, and about 2 per cent rossed.

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[1] J. H. Thickens: "Experiments with Jack Pine and Hemlock for Mechanical Pulp." Dept. of Agriculture, Forest Service Forest Products Laboratory Series, June 11, 1912.

[2] The usual proportion is from 70 to 84 per cent ground pulp to from 16 to 30 per cent sulphite.

The use for pulp of waste material left after lumbering has recently been introduced in parts of Pennsylvania (see Pl. II, fig. 2). Hemlock tops and broken and defective logs are peeled, cut into 5-foot lengths, piled in the woods, and sold by the cord. The success of this practice disposes of the contention that the knots in hemlock tops make their use for pulp impracticable. From 250,000 to 260,000 cords of slab wood and other sawmill waste are now consumed every year for pulp. About 85 per cent of this is manufactured as sulphite pulp, and practically all the rest as ground wood. In 1908 hemlock formed 41 per cent of the sawmill waste used, and its average value was $4.07 per cord—about two-thirds that of hemlock cordwood in the round. In Wisconsin, sawmills often sell their hemlock slabs to the paper mills for $3 per cord, dry, or $2 green.

The cost and value per cord and per thousand board feet of pulpwood vary somewhat in different regions, and there are constant fluctuations due to changing business conditions. The price also depends upon whether the wood is sold peeled, rossed, or with the bark on. In 1909, according to census reports, wood with the bark on sold for $5.98 a cord, while peeled wood brought $6.58, and the small amount of rossed wood $12.31 a cord.

The average f. o. b. value per cord of hemlock in different regions in comparison with other pulpwoods is shown in Table 4.

TABLE 4.—*Average f. o. b. value per cord of hemlock pulpwood compared with other species.*

[Compiled from census reports for 1907, 1908, and 1909.]

| Region. | Year. | Hemlock. | Spruce (domestic). | Balsam. | Poplar (domestic). |
|---|---|---|---|---|---|
| Total | 1907 | $5.68 | $8.55 | $7.59 | $7.85 |
| | 1908 | 6.02 | 8.76 | 7.23 | 8.01 |
| | 1909 | 6.30 | 9.32 | 8.28 | 7.96 |
| New England | 1907 | 7.10 | 8.48 | 8.30 | 7.51 |
| | 1908 | 7.18 | 8.51 | 7.58 | 7.54 |
| New York | 1907 | 6.79 | 8.13 | 9.17 | 8.25 |
| | 1908 | 7.47 | 8.58 | 8.22 | 8.49 |
| Pennsylvania | 1907 | 5.13 | 9.26 | .......... | 8.62 |
| | 1908 | 5.05 | 10.94 | 9.53 | 9.16 |
| Lake States | 1907 | 5.83 | 9.88 | 5.84 | 4.45 |
| | 1908 | [1] 6.36 | 10.05 | 6.39 | 4.93 |

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[1] During the financial depression of 1908 the market value of hemlock logs in northern Wisconsin dropped in some cases to $7 per thousand board feet (equivalent to $3.50 per cord) f. o. b. cars. No logger would deliver hemlock pulpwood for less, and of this amount, $2.50 would probably go to the jobber to whom the work was let out.

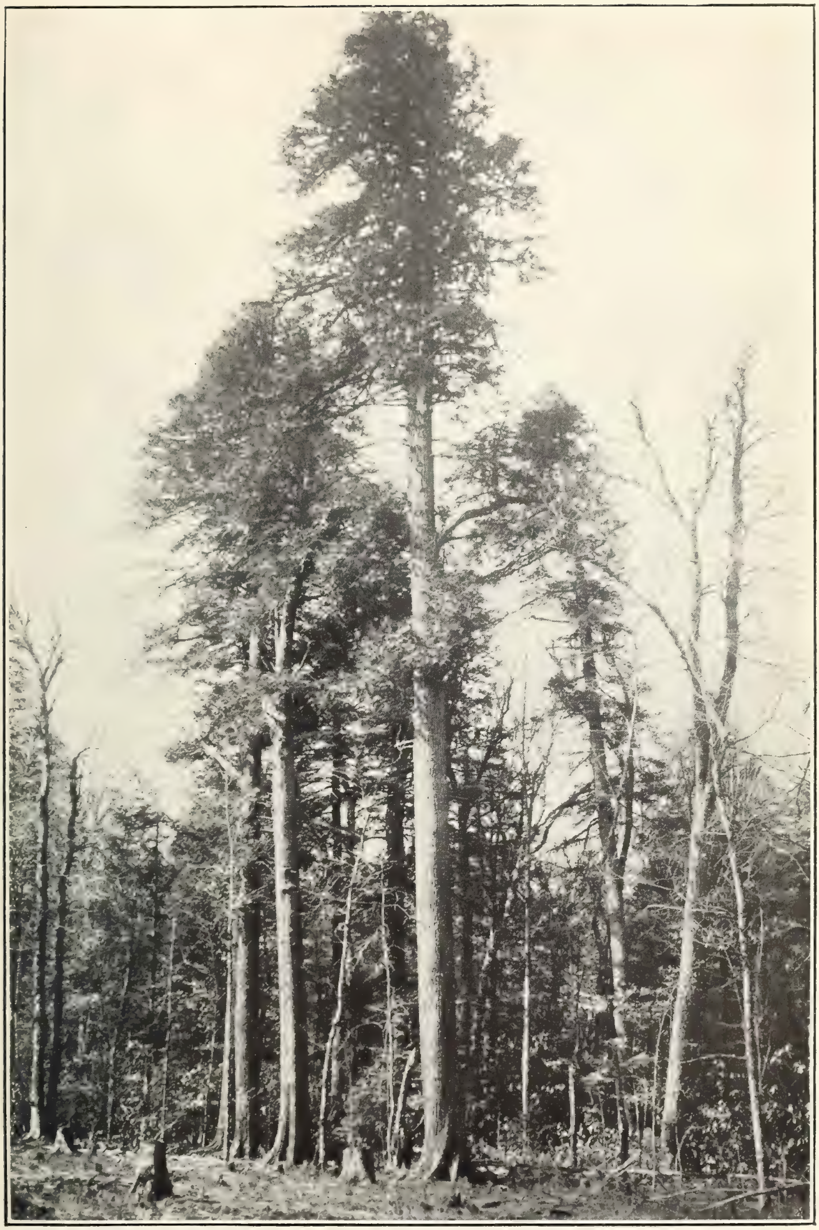
Pulp mills may pay as high as $12 per thousand board feet, in the log, and accept crooked logs. This fact is important in view of the low "mill run" value of hemlock lumber, which is rarely much over $15 per thousand board feet at the mill, and for which crookedness is a more or less serious defect. The pulp mills also prefer to receive their wood peeled, and will often pay $1 more per thousand board feet for peeled than for unpeeled logs. Peeled logs are cheaper to transport and more durable than unpeeled ones, and there is no expense for rossing. On the other hand, stripping tanbark from saw logs often greatly reduces their value, due to the serious checking which results. Bark peeling can be done more profitably when logs are cut for pulp than for lumber.

The value of hemlock cordwood in Wisconsin is about $3.50 per cord when logs are selling at $8.50 per thousand board feet, and about $4 per cord when logs sell at from $9 to $12 per thousand. The cost of getting out cordwood is about $2.50 or $3 a cord. Until quite recently hemlock pulpwood stumpage at many places in Wisconsin has been valued at 50 cents a cord.

### TANNING.

Hemlock bark has been used in tanning practically ever since the beginning of the industry in America. Oak bark is preferred, since it makes the leather softer, more pliable, and less permeable to water than does hemlock; but there is not as much of it, and for many years its annual consumption in tanning has been less than half that of hemlock. With the introduction of tanning extracts, hemlock and oak were the first native species to be used, but after the process by which extract could be made from chestnut wood was perfected, about 1900, the latter species became the leading source of supply. In 1909 it supplied practically half the extract used, while the amount supplied by hemlock had fallen to about 3 per cent of the total quantity. The amount of hemlock bark made into extract was never a large part of the total hemlock bark consumed in tanning; in 1900 it formed about 1 per cent, in 1907 and 1908 slightly exceeded 8 per cent, and in 1909 had fallen to less than 3 per cent.

Table 5 gives the total annual consumption of tan bark and extract in the United States, with the proportion supplied by each of the leading native species, and the value per cord of hemlock and oak bark. The figures are from census reports for different years. For convenience, the percentage figures, when they include decimals, are expressed as the nearest whole number.



A MATURE HEMLOCK TREE.

The clean, columnlike bole indicates an advanced age. North Carolina.

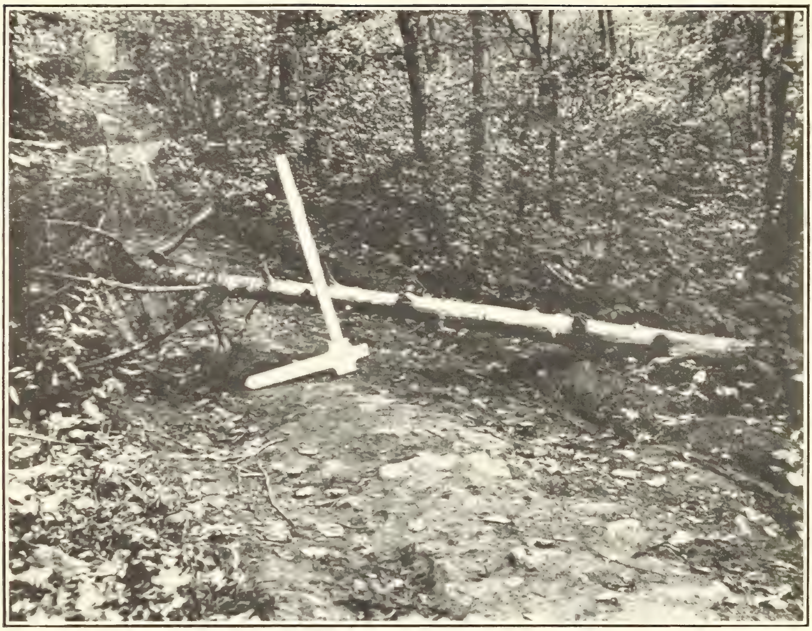


FIG. 1.—BARK PEELING TO A DIAMETER OF LESS THAN 4 INCHES IN THE TOP.

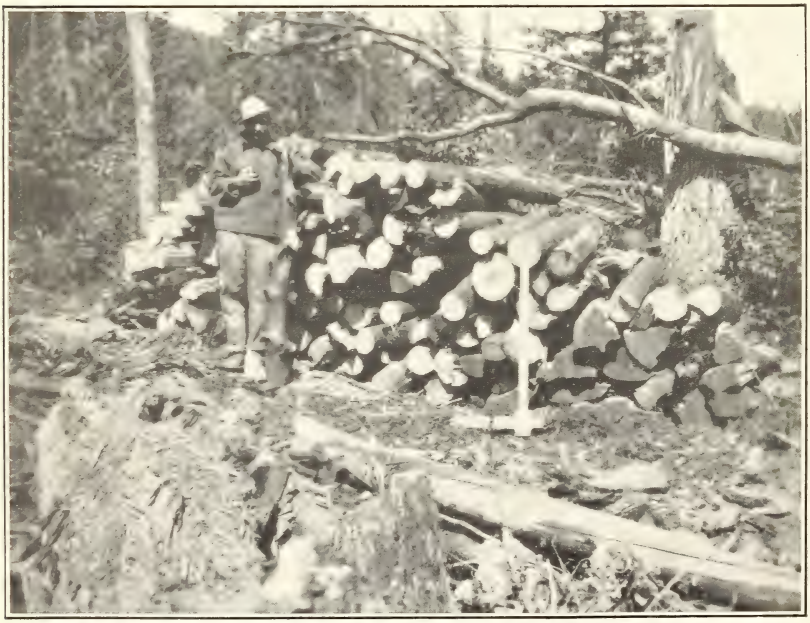


FIG. 2.—HEMLOCK TOP WOOD AND BROKEN LOGS ONCE LEFT TO ROT AFTER LOGGING NOW BRING A GOOD PRICE AS PULPWOOD.

CLOSE UTILIZATION OF HEMLOCK IN PENNSYLVANIA.

TABLE 5.—*Consumption of tanning materials: 1900, 1905–1909.*

[Compiled from census reports for these years.]

| Year. | Consumption of bark. | | Proportion of total. | | Average price per cord. | |
|---|---|---|---|---|---|---|
| | Total. | Hemlock. | Hemlock. | Oak. | Hemlock. | Oak. |
| | *Cords.* | *Cords.* | *Per cent.* | *Per cent.* | | |
| 1900 | 1,616,065 | 1,170,131 | 72 | 28 | $6.28 | $7.12 |
| 1905 | 1,104,045 | 799,755 | 73 | 27 | 6.32 | 10.44 |
| 1906 | 1,371,342 | 931,152 | 68 | 30 | 8.49 | 10.87 |
| 1907 | 1,214,401 | 815,840 | 67 | 31 | 8.60 | 10.51 |
| 1908 | 1,127,400 | 810,231 | 72 | 27 | 8.89 | 10.80 |
| 1909 | 1,078,910 | 698,365 | 65 | 30 | 9.21 | 10.90 |

| Year. | Consumption of Extract. | | Proportion of total. | | | Average price per barrel. | | |
|---|---|---|---|---|---|---|---|---|
| | Total. | Hemlock. | Hemlock. | Oak. | Chestnut. | Hemlock. | Oak. | Chestnut. |
| | *Barrels.* | *Barrels.* | *Per ct.* | *Per ct.* | *Per ct.* | | | |
| 1900 | 67,043 | 12,812 | 19 | 81 | ........ | $11.78 | $10.14 | ........ |
| 1905 | 292,399 | 52,430 | 18 | 64 | 17 | ........ | ........ | ........ |
| 1906 | 658,777 | 68,811 | 10 | 9 | 39 | 12.31 | 9.91 | $9.13 |
| 1907 | 729,599 | 80,267 | 11 | 8 | 38 | 12.06 | 10.38 | 9.51 |
| 1908 | 784,202 | 81,617 | 10 | 6 | 37 | 12.78 | 10.60 | 9.72 |
| 1909 | 773,635 | 21,725 | 3 | 10 | 48 | 12.72 | 9.52 | 9.80 |

This table shows that there has been a gradual but steady decline in the quantity and an increase in the value per cord of hemlock bark used directly by the tanneries. By far the largest part of the hemlock bark and extract used is produced in the States of Pennsylvania, Wisconsin, Michigan, New York, and West Virginia, ranking in importance in the order named.

Sales of hemlock bark, though nominally by the cord, are actually by the ton, and in most cases the cord must weigh 2,240 pounds. The bark is peeled in the spring and piled in the woods. The peelers are paid by the bulk cord—8 by 4 by 4 feet. Trees as small as 8 inches in diameter breast-high are sometimes peeled, but the bark of small trees is thin and light, and rolls up when dry, so that a cord (by weight) may be a pile 12 feet instead of 8 feet long. Wisconsin bark is thinner and lighter than bark from Michigan, and tanners will not pay as much for it. Lumbermen commonly assume that a half cord of bark can be obtained for each 1,000 board feet of lumber. This is about right for trees 20 inches in diameter. Smaller trees yield more bark per 1,000 board feet and larger trees less. Economy in bark peeling is rapidly increasing, and trees are now peeled to much smaller diameters in the top than formerly (Pl. II, fig. 1).

The volume of bark obtainable from trees of different sizes is shown in Tables 18, 19, and 20, Appendix.

## MINOR USES.

### SHINGLES.

Because of the prevalence of shake, hemlock is not well adapted for shingles, unless these are carefully sawed and well graded. It ranks seventh or eighth among the species most used. Census figures show a steady decrease in the manufacture of hemlock shingles from 1899, when nearly 392 million were made, until 1911, when only about 26 million were produced. These figures correspond to 3.2 per cent and 0.2 per cent, respectively, of the total annual production of shingles.

### CROSSTIES.

About 2.5 per cent of all crossties used in the United States are of hemlock, which ranks about ninth among the tie-producing species. Between 1906 and 1911 the annual production of hemlock ties increased from 2,058,000 to 3,686,000. Nearly all of these are hewed ties and are used by steam railroads. Oak and cedar are more durable, but hemlock compares favorably with the other woods used, and is said to hold spikes better than the cedar without tie plates. The average cost of hemlock ties is from 28 to 38 cents, which is, in general, lower than for other species.

Untreated hemlock ties have been estimated[1] to last about 5 years, which is also the estimated life of untreated beech, birch, and maple ties. The estimated duration of cedar ties is 11 years; of white oak, 8; of chestnut, 7½; of tamarack and spruce, 7; and of black oak, 4 years. Preservative treatment is said to triple the life of hemlock ties. In 1911, 535,255 hemlock ties—14.5 per cent of all produced—were treated with preservative, nearly all—98.5 per cent—with a mixture of zinc chloride and creosote; the remainder with creosote alone.

### SLACK COOPERAGE.

Slack cooperage is primarily a hardwood industry, and aside from pine, which leads in the production of heading and is second in that of staves, the conifers are but poorly represented. Hemlock has never supplied much material for this industry, and its importance is rapidly diminishing. In 1909, which is the last year for which hemlock is listed separately in census statistics, it ranked sixteenth among the species supplying the industry, and contributed less than 1 per cent of either staves or headings. The annual production of hemlock staves is from 10 to 12 millions, and of headings, about 1,200,000 sets.

### VENEER.

A very small amount of hemlock—less than 1 per cent—is used annually for veneer manufacture. In 1909, hemlock ranked twentyfourth among veneer-producing species, with an annual consumption of 207,000 board feet of logs. Most of the hemlock veneer is made in New York, while Maine, Pennsylvania, Ohio, North Carolina, and the Lake States contribute small amounts. It is employed chiefly in the manufacture of shipping packages of various kinds, laminated or built-up lumber, etc.

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[1] "Wood Preservation," by W. F. Sherfesee and H. F. Weiss, in Report of National Conservation Commission, 60th Cong., 2d sess., S. Doc. 676, 1909, p. 663.

Because of heart defect (knots, shake, and decay) hemlock cores left after veneer production are of little value for anything but fuel.

## STRUCTURE AND DEVELOPMENT OF THE TREE.

During youth, hemlock is the most graceful and beautiful of eastern conifers. Though young trees in dense shade are usually flattened and unsymmetrical, saplings which receive enough light will develop a straight, slender, tapering stem, and a sharply conical, symmetrical crown. The terminal shoots and branch tips lack the rigidity common to pine, spruce, and fir, and the crown is formed of slender, horizontal branches with graceful sprays of branchlets and twigs. The branches are rather uniformly distributed over the stem, though not in regular whorls, as in white pine. The "leader," or terminal shoot, droops in a direction away from the prevailing wind.

Full-grown hemlocks have very straight, symmetrical, undivided trunks. The taper is greater than that of white or red pine, or, in fact, of most of its common associates, and is due to the remarkable persistence of live branches along the stem. The crown is very long and dense and of a conical shape. In mature trees it commonly covers the upper two-thirds of the stem, and may be 60 or 70 feet long by 30 or 40 in total spread. It is formed of slender, horizontal, or somewhat drooping limbs, which clothe the tree densely and evenly on all sides. When the growth is vigorous and the side shade very dense, the limbs of mature trees are killed to a height of 50 or even 60 feet above the ground, but the dead limbs are retained tenaciously, so that even under these conditions an actual clear length of 30 feet is uncommon except in very old trees (Pl. I). The mature trunks usually bear numerous small, sound, dead stubs almost to the ground, and good-sized limbs at 20 or 25 feet from the ground.

When full grown, hemlock varies in total height from about 100 feet, in good soil in the western part of its range, to over 160 feet in mountainous portions of West Virginia, North Carolina, and Tennessee. Diameters at breastheight of 3 or 4 feet are now exceptional, though trees 5 and even 6 feet in diameter have been measured. One tree cut near Hermon, N. Y., measured 115 feet in height, 5 feet in diameter, and contained 5,562 board feet.[1] Trees yielding 10,000 board feet each are reported to have been cut in Tucker County, W. Va. Such dimensions sometimes are found to correspond to an age of 500 or 600 years.

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[1] From the "Paper World," Jan. 4, 1902.

The average contents in cubic feet and board feet of hemlock trees of different heights and diameters are given in Tables 12 to 17, Appendix. In addition, Tables 21 and 22, Appendix, show the diameters, inside bark, at different heights from the ground corresponding to the small ends of 8 and 16 foot logs.

## THE WOOD.

Hemlock wood is soft, light, stiff, but brittle, not strong, splintery, and commonly cross-grained. Its worst defect, aside from a tendency to decay, is "shake," which is the tearing apart of the wood between annual rings caused by the tree bending in the wind. This condition is very common, especially in old trees. "Shaky" lumber splits so easily as to be worthless for many purposes.

In color the wood is light buff with a red-brown tinge. In structure it differs from pine and spruce wood in the more abrupt transition between the hard, dark summerwood and the soft, light, springwood, a contrast which gives the lumber a handsome figure. The fuel value of hemlock is low, though slightly higher than that of white pine. The per cent of ash is 0.46. Sargent[1] computes the specific gravity of absolutely dry hemlock wood at 0.4239, a cubic foot weighing 26.42 pounds. The shipping weight per thousand board feet of ordinary seasoned rough lumber varies from 2,400 pounds for 1-inch board to 3,500 pounds for heavy timbers.

## BOTANICAL CHARACTERISTICS.

### BARK.

The bark of merchantable trees in the Lake States comprises about 19 per cent of the total cubic volume, and this proportion varies but little with the size of the tree. In the Southern Appalachians the proportion varies from 15 per cent for 6-inch trees to 19 per cent for trees 26 inches and over. When 15 or 20 years old the bark begins to break up into thin, partly loosened flakes, or scales, and still later becomes traversed by deep, longitudinal fissures. In old trees the bark is often 2 or 3 inches thick at the stump, gradually decreasing with height to a thickness of from 0.3 to 0.5 of an inch at the point where the tree is 6 inches in diameter. It consists of two distinct layers, the inner relatively very thin, white, and fibrous, the outer thick, deep red, and brittle.

### ROOTS.

Seedlings form a slender taproot during the first year, which is later lost in the development of lateral branches. These are numerous, and the older ones become very large. The latter are covered with a thick firm bark, the outer and thicker layer of a pale red color, the very thin inner layer white. On the whole, hemlock is a shallow-rooted species, and can thrive on very shallow soil. In deep soils, however, the roots often penetrate to some depth.

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[1] C. S. Sargent, "Silva of North America," vol. 12, p. 65, 1898.

### LEAVES.[1]

The leaves are small, flat, and narrow, and differ from those of other northeastern conifers, except Carolina hemlock and the Canadian yew or ground hemlock, in that their bases are contracted into a very short stalk or petiole. (See *c*, fig. 2). They are usually from one-third to two-thirds of an inch long and about one-fifth as wide. Their color when they first appear is a fresh, light green, which soon changes to a dark, lustrous green on the upper and whitish green on the under surface, where the stomata are located. The leaves fall during their third season.

### BUD SCALES.

The few exterior scales of both flower and leaf buds are thick and dark brown in color, while the inner scales are numerous, whitish-green, becoming brown with age, thin, but of an exceedingly firm structure. The scales remain persistent after the buds have expanded, those of the leaf buds not wholly disappearing until the fifth or sixth year. Up to this age the persistence of the scales affords a ready means of determining the age of a branch.

### FLOWERS.

In the latitude of central New York the flowers expand about the first of June. The male flowers appear in the axils of leaves on shoots of the previous year, or less frequently on twigs which are two or sometimes three years old (fig. 2). The female flowers are borne singly at the ends of the twigs.

### CONES.

The female flower, after fertilization, grows rapidly, and by October becomes the ripened fruit—the cone. (See *d*, fig. 3.) Cones are from one-half to three-fourths of an inch long and of equal breadth when dry and the scales expanded, but only half as broad when closed. They are pale green in color until maturity, when they become dark brown. Only about 20 of the scales in the center of the cone are seed bearing, the others being small and rudimentary. In a mature cone, when dry, the scales are widely separated from each other, standing at an angle of about 45 degrees with the axis, but when wet they become appressed and closely overlap each other.

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[1] The description of the following parts of the tree are drawn largely from a manuscript report on the general structure and anatomy of hemlock by Prof. Atbey N. Prentiss, of Cornell University.

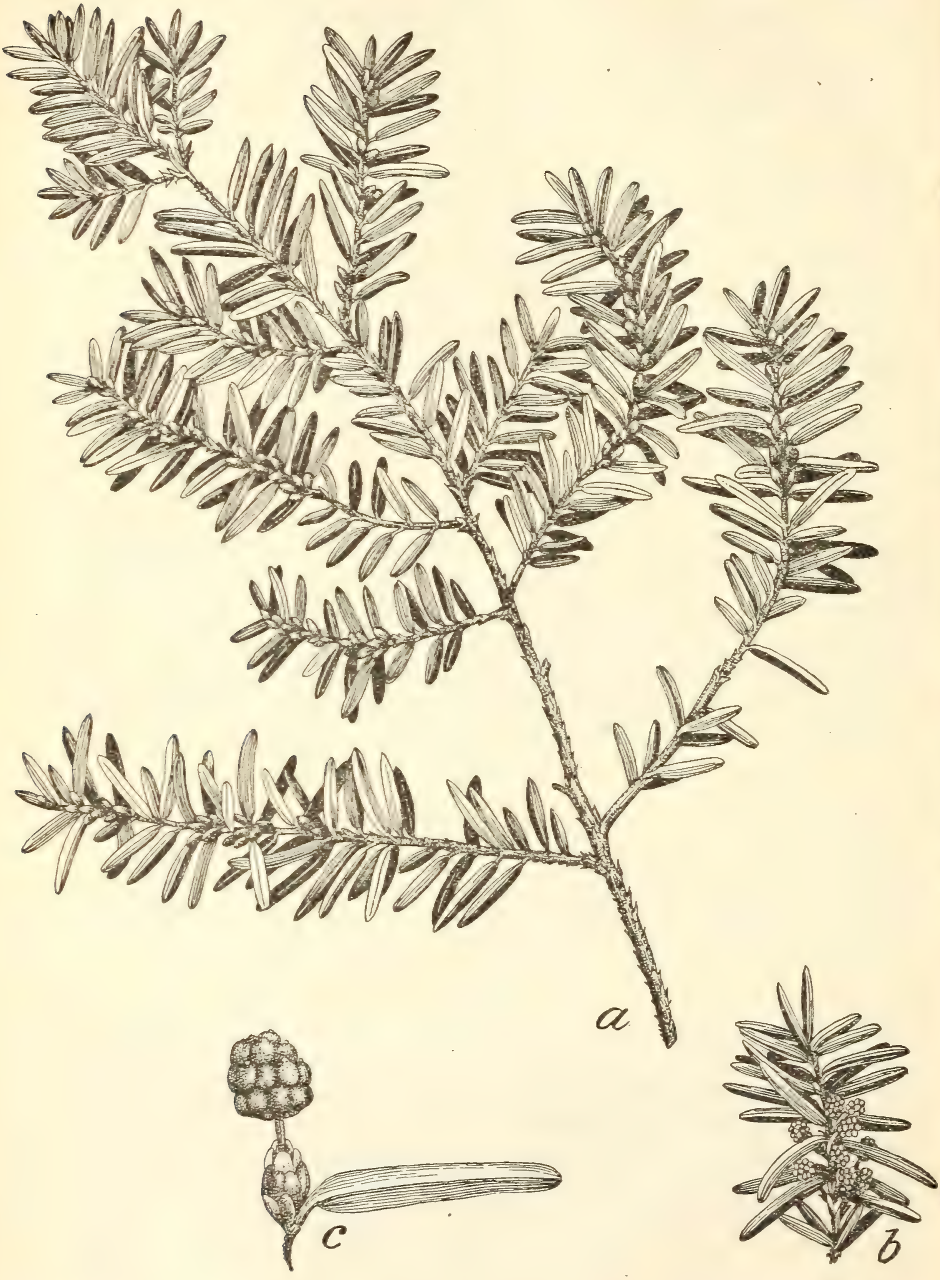

FIG. 2.—*Tsuga canadensis.* *a*, Branchlet showing staminate flowers in early spring; *b*, staminate flowers fully developed; *c*, detached staminate flower, enlarged.

The cones are extremely sensitive to moisture, a small amount of water causing the scales to close rapidly. When thoroughly wet the scales of a cone become completely closed, in some cases within 10 minutes and in most cases within 20 minutes. Even a damp atmosphere, without the actual contact of water, will cause the cones to close to some extent.

The advantage to the species of this property of the cone is apparent. The cones when mature expand their scales so as to permit the seeds to escape, but as the latter are attached to a membranous wing which adheres to or rather forms a part of the inner face of the scale, they do not easily fall out. A passing shower or a rain causes the scales to close, again to open as the air becomes dry. This process continues for many months, with the effect of loosening the seeds successively from autumn until spring, and thus a bearing tree makes a succession of sowings extending over a considerable length of time. As a result the wind, blowing during this period from different points, carries the seed now in this direction and now in that, and thus a fruiting tree stands in the center of a considerable area which it has sowed with seed.

### SEED.

The seed (see *f* and *g*, fig. 3) is about one-sixteenth of an inch long and about two-thirds as broad. The attached wing, an exceedingly delicate and almost transparent membrane, extends about a fourth of an inch beyond the end of the seed, and is an eighth of an inch broad at its widest point. On the under side, next to the cone scale, are a number of minute glands or vesicles, usually from 4 to 8, each containing a minute drop of oil. The seed of the Carolina hemlock has 15 or 20 vesicles, which are much smaller in size than those of the common species.

According to Forest Service determinations, there are about 400,000 clean seed (without wings) per pound. The seeds weigh 1.13 grams (0.04 ounce) per 1,000, and the germination per cent is from 30 to 60.

### MANNER OF GROWTH.

In the climate of central New York the growth of a vigorous tree usually begins during the first half of May. The terminal buds are the first to open, and in about two weeks develop into shoots a half inch long, thickly set with the half-grown, yellowish-green leaves. The dark-green twigs and branches appear as though fringed with gold; and it is now that the hemlock tree takes on its most striking and peculiar beauty. The shoot continues its growth during the season, being constantly tipped with a rosette of small, forming leaves, while those previously formed are scattered on the constantly growing stem.

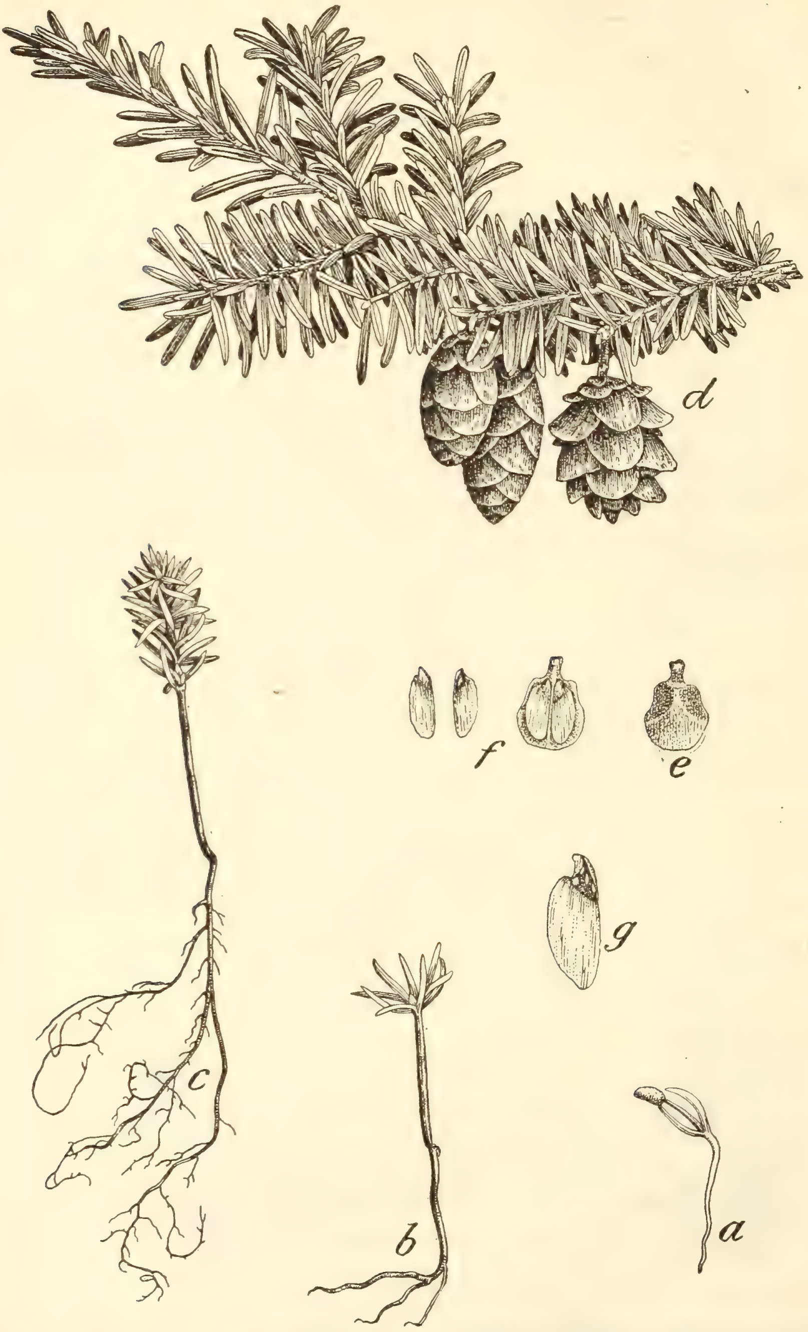

FIG. 3.—*Tsuga canadensis.* *a*, Seedling a few days old; *b*, seedling, one month old; *c*, seedling, one year old; *d*, mature foliage and ripe cones; *e*, lower side of detached cone scale; *f*, upper side of cone scale with its seeds and views of latter detached; *g*, lower side of seed showing resin glands (twice natural size).

The stem does not grow throughout its whole length, but at a certain point it becomes mature, and growth ceases. During the season this point lies something more than an inch back from the tip, and is constantly moving forward as the stem grows, until at the close of the season it coincides with the end of the stem.

While the shoot of the season is growing in length, it is also at the same time developing lateral growths or branches. (See *a*, fig. 2.) These lateral growths begin to appear about the middle of June, in the form of minute rosettes of leaves similar to that at the end of the main shoot, and grow in a manner similar to the main stem, only far more slowly. In vigorous plants the main shoots often reach a length of 8 to 12 inches, while the strongest of the lateral shoots scarcely reach an inch in length.

Winter buds begin to form about the middle of September at the end of the main shoot and of its branches, and also in the axils of many leaves of the main shoot.

The tree reaches its fruiting stage usually when from 20 to 40 years old and from 15 to 25 feet in height. The staminate flower buds begin to develop about the 1st of July and by the last of the month have become well formed. In general appearance they resemble the lateral leaf buds, but are twice the size and more conical in form. Sometimes every leaf, or at least a portion of a flower-bearing shoot, has a flower bud in its axil.

The pistillate flower buds also begin to develop early in July, but grow more slowly than the staminate buds. When fully formed they are about the same size as the latter, but their exterior scales are of a much firmer texture and deeper brown in color, while their bases are covered with the overlapping scale processes of the neighboring leaves. Though both kinds of flower buds occur on the same general branch, they are both rarely borne on the same shoot. In other words, while the plant as a whole is monœcious, the shoots of the season are diœcious.

A wide difference exists in the vigor and size of flower-bearing and leaf-bearing shoots. On young and thrifty trees the latter are often 8 to 10 inches in length, while on trees of fruiting age they rarely exceed an inch or an inch and a half in length.

## ASSOCIATED SPECIES.

In one part or another of its range hemlock grows in mixture with a number of tree species. There are, however, four kinds of forest in which it is a characteristic and important element; hemlock in mixture with either yellow birch, beech, or sugar maple, or with all three; hemlock with white pine; hemlock with red spruce; and hemlock in practically pure stands. Other species than those just mentioned are always scattered through these forests, and an extra abundance of one or more of them in mixture with hemlock may give rise to distinct local forest types. Among such species are white spruce, balsam fir, white and rock elms, basswood, paper birch, sweet birch, red maple, and black cherry. In the South, yellow poplar, shagbark and shellbark hickories, white, red, and post oaks, and cucumber often grow with hemlock in the coves, while black, scarlet, and chestnut oaks, pignut and mocker nut hickories, and chestnut are its usual associates on slopes and ridges.

## EFFECT OF LIGHT, SOIL, AND MOISTURE ON THE COMPOSITION OF THE STAND.

The heavy foliage of hemlock adds greatly to the density of any stand in which the tree grows. Since it will endure a heavier shade than any of its associates, hemlock finds little difficulty in establishing itself under them, even when their crowns form a fairly dense cover. For this reason the forests of which it forms a principal part nearly always contain trees varying widely in age and size. This is especially true when it grows in mixture with species like beech, sugar maple, spruce, and balsam, which are also shade enduring. Trees like white pine, which require more light than hemlock, can succeed in mixture with it only by growing more rapidly and to a larger size, thus keeping their crowns above or at least as high as those of the hemlocks. In mixed stands of white pine and hemlock there is usually a dense understory of the latter species, which is the only one able to establish itself in the shade of the crowns. In this way hemlock is able to creep into stands of pine and other species, and by its superior shade endurance gradually assume predominance. (Pl. III.)

Under the particularly dense shade of hemlock and spruce stands, and in thickets of rhododendron and other heavy-foliaged undergrowth, hemlock seedlings find it exceedingly difficult to survive, and the few which do survive grow with extreme slowness as long as the shade remains heavy. (Pls. IV and V.) When, however, light is admitted not too abruptly they rapidly recover from suppression.

Hemlock is essentially a tree of fresh or moist soils; in other respects its soil requirements are not exacting. In mixture with hardwoods it usually grows on loamy soils, ranging from sand loam to clay loam, rich in decayed vegetable material; and with white pine on sandy soils, well mixed with humus. Hemlock will grow on limestone soils, if not too dry, as well as on moist, almost swampy, loamy clays. Like all its common associates, it does best on deep, fertile, moist, but well-drained soils, where it and the hardwoods tend to crowd out the more light-needing white pine.

The shallow roots of hemlock are extremely sensitive to drying out of the surface soil, which in part accounts for the death of trees exposed to increased light, as when a road is cut through the woods, or near-by trees are removed in lumbering.

In mountainous regions hemlock usually occupies the cool, moist, northerly and easterly slopes, coves, benches, and sides of ravines, often reaching the edges of streams, but avoiding extremely wet and swampy places. On north and east slopes of ridges it often ascends to the crest, and may grow along the edges of rocky cliffs and bluffs. In New Hampshire it ranges from near sea level to about 2,400 feet, but in Georgia and Alabama it is not found below an elevation of about 800 feet, and reaches this level only in cool and humid situations.

## REPRODUCTION.

Hemlock is a prolific seed bearer, but reproduces poorly. Trees receiving a moderate amount of light begin to bear seed when from 30 to 50 years old. As a rule seed is produced abundantly every two or three years, but ordinarily only from 30 to 60 per cent of the seeds are fertile. The cones mature in a single season, and the seeds fall from them during the late autumn and winter, germinating in the spring, from March to the end of May. On account of their small size and their large, membranous wings, the seeds may be borne considerable distances by the wind. They will germinate and take root in poorly drained situations, on moss-covered logs and decayed stumps as well as in fresh, mineral soil; but the best seed bed is a moist, well-decomposed leaf litter in which the seeds become completely buried.

Too much or too little shade will kill hemlock seedlings. For this reason reproduction is rarely found either under the heaviest shade of the parent trees or in clearings and burned-over areas, but is usually abundant in the more open portions of the hemlock forest or under the lighter shade of hardwoods or pine in mixture. If the water in the soil is not stagnant, more seedlings will survive in very moist than in relatively dry situations. The seedlings grow best when in deep, moist layers of mellow decaying leaves and twigs overlying fresh but well-drained loamy soils. The decay of the leaves and twigs breaks down their chemical structure and releases various food materials for the seedling hemlock. These materials become available largely or only through the agency of certain fungi, called mycorrhiza, which exist as felted layers of fine, thread-like mycelium, completely inclosing and even penetrating the rootlets. Many of the threads extend out into the mass of decaying humus, and through these the products of decay are conducted from the decomposing leaves to the felt, and thence into the rootlets, where they become serviceable for nutrition and growth. It is probable that the best conditions for the development of hemlock mycorrhiza exist where the soil is sweet or only slightly acid and where a good crown cover is maintained.[1]

Hemlock reproduction is rarely found in clearings, a condition for which fire is chiefly responsible, though other causes, such as intense sunlight and evaporation, no doubt play a part. Fire, however, while actually promoting the reproduction of many species by exposing the mineral soil, may at the same time entirely prevent that of hemlock by destroying the organic constituents of the forest soil. In the relatively few hemlock regions from which fires have been kept out after logging remarkably thrifty stands of second growth have often developed. Such second-growth hemlock in the Tionesta Valley and elsewhere in the northern Alleghenies is undoubtedly due to the absence of fires in these localities in the past, while the entire absence of hemlock in other localities as favorable to its growth can be attributed to the burning of seedlings and soil.

Even-aged stands of hemlock second growth are very rare. Small groups occur in protected valley bottoms and lower slopes in the Allegheny and Catskill Mountains. One of these, which occupied a few square rods in a ravine bottom, was 40 years old and contained about 12 thrifty trees per square rod, the dominant ones 30 feet high and 3 inches in diameter. The stand was very dense, and there were many small dead trees which had been killed by the shade.

## RATE OF GROWTH.

Under the shade of the mature forest the growth of the average hemlock is extremely slow. The period of suppression commonly lasts from 30 to 70 years, but if the shade remains dense it may continue for more than 200 years. Even at an advanced age, however, a suppressed tree will respond to an increase in its light supply by a proportionate increase in its height growth. If it ultimately attains a dominant position in the stand with plenty of light, it will grow fairly rapidly in diameter and volume.

Individual hemlocks show a wide variation in rate of growth, according to the amount of light they receive. Trees of the same diameter in the same stand may differ in age by more than a century. The average growth of hemlock obtained from measurements of many individual trees therefore represents many different degrees of suppression and does not indicate what a tree would do if given full light. The maximum growth, similarly obtained, more closely resembles the growth of a tree in the open, though even here the retarding influence of suppression is felt to some extent.

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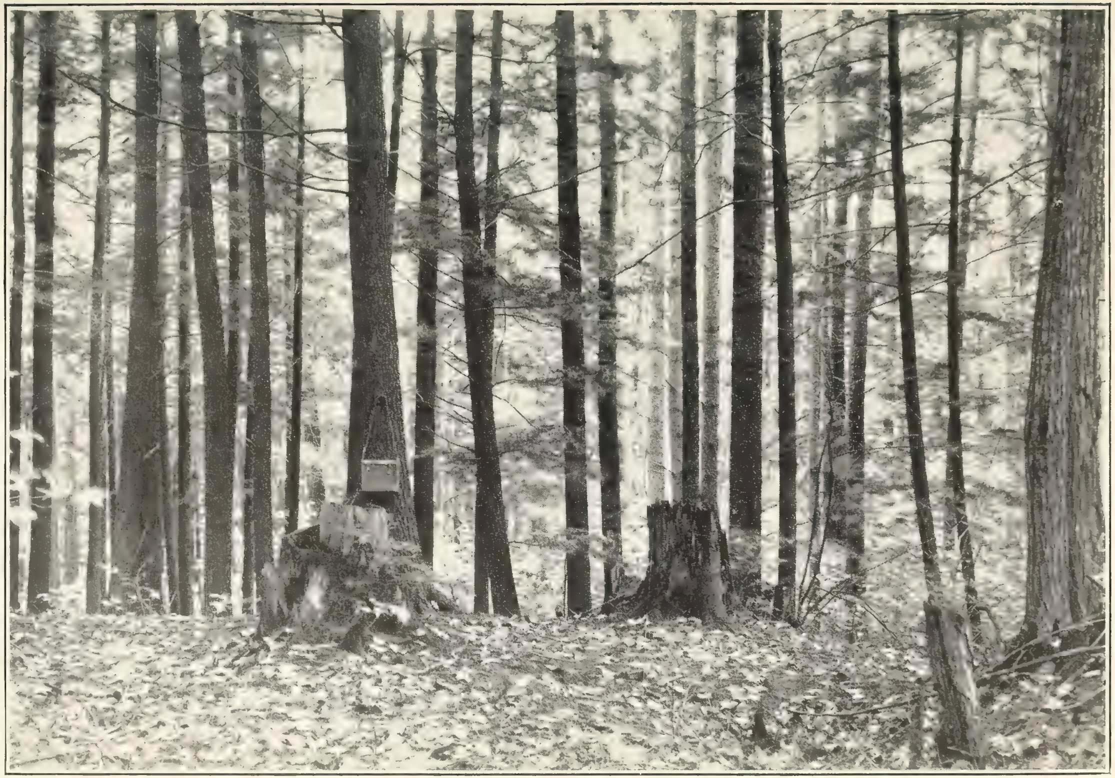
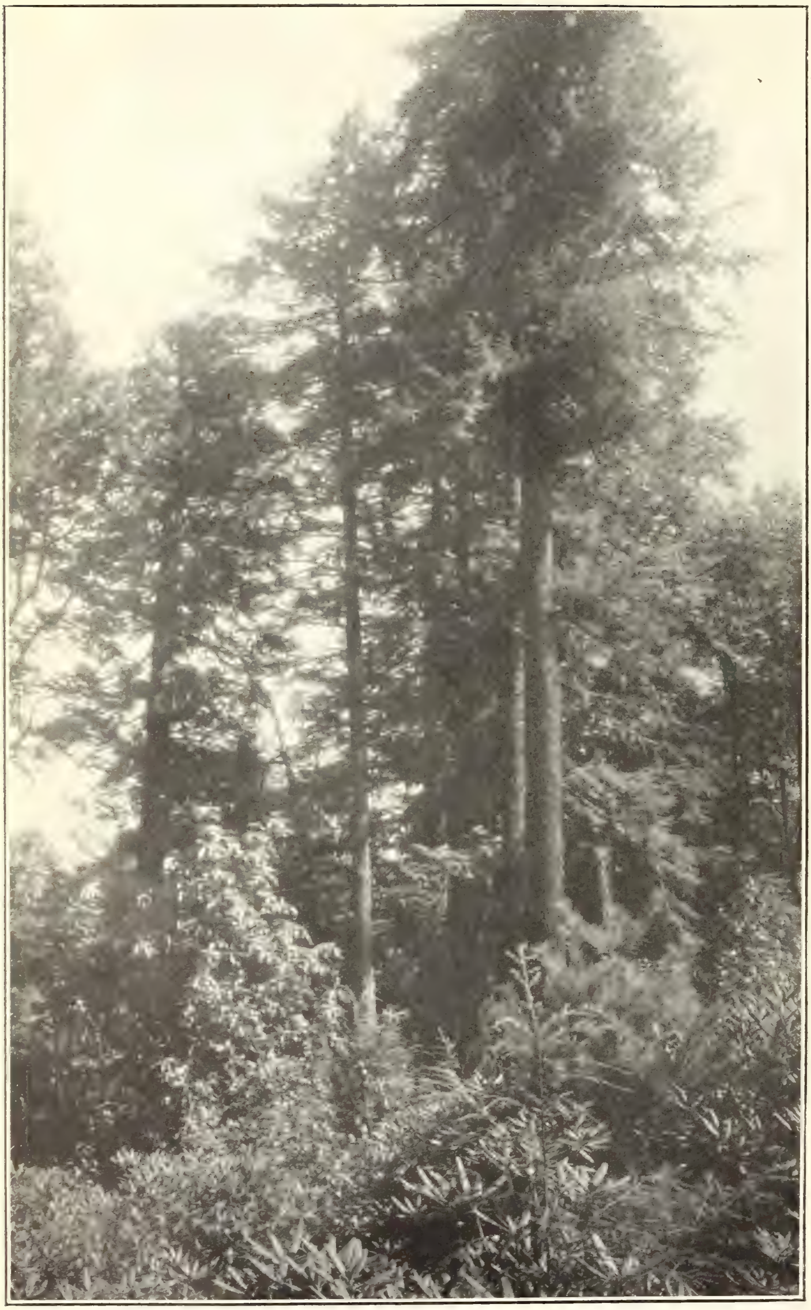
[1] Cf. "Roots of the Hemlock," by S. H. Harlow, in Jour. N. Y. Bot. Gard., July, 1900, Vol. I, No. 7, 100–101.



THE STORY OF THIS POLE STAND OF HEMLOCK IS TOLD BY THE WHITE PINE STUMPS IN THE FOREGROUND.



GROUP OF MATURE HEMLOCK, MITCHELL COUNTY, N. C., SHOWING HEMLOCK AND PINE REPRODUCTION COMPETING WITH RHODODENDRON.

Local variations in growth are also caused by climate and the quality, depth, drainage, and moisture of the soil. Growth is most rapid on the best soils. Hemlock is especially favored by a temperate, humid climate and long growing season, combined with moist but well-drained soils—conditions which it finds in the coves and slopes of the southern Appalachians.

Tables 8 to 11 show the growth of hemlock in localities in various parts of its range. The tables give the maximum, minimum, and average rates of growth in height, diameter, and volume, and are based on measurements of many forest-grown trees differing widely in amount of suppression. Though not based on crown-class distinctions, the maximum figures may safely be regarded as representing the average growth of dominant trees on good soil, and the minimum that of suppressed trees which have reached merchantable size. The average figures, however, may represent the growth both of trees of the middle crown classes and of dominant trees in situations of poor quality. These data were averaged separately for diameters, heights, and volumes, so that only an approximate relation exists between the values for any given age. Furthermore, the variation in height and volume among trees of a given diameter is considerable, as shown by the volume tables in the Appendix.

TABLE 8.—*Growth of hemlock in Leelanau County, Mich.*[1]

| Age. | Diameter, breast-high. | | | Height. | | | Volume. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inches. | | | Feet. | | | Cubic feet. | | | Board feet. | |
| | Minimum. | Average. | Maximum. | Minimum. | Average. | Maximum. | Minimum. | Average. | Maximum. | Average. | Maximum. |
| *Years.* | | | | | | | | | | | |
| 20 | 0.3 | 0.7 | 2.0 | 6 | 8 | 18 | ........ | ........ | ........ | ........ | ........ |
| 30 | .6 | 1.3 | 3.9 | 7 | 12 | 31 | ........ | ........ | ........ | ........ | ........ |
| 40 | .9 | 2.1 | 5.7 | 8 | 16 | 42 | ........ | ........ | 2.2 | ........ | ........ |
| 50 | 1.3 | 2.9 | 7.6 | 10 | 20 | 53 | ........ | ........ | 6.6 | ........ | 13 |
| 60 | 1.6 | 3.8 | 9.4 | 11 | 25 | 62 | ........ | ........ | 12.4 | ........ | 31 |
| 70 | 2.0 | 4.7 | 11.1 | 13 | 30 | 70 | ........ | ........ | 20.0 | ........ | 56 |
| 80 | 2.4 | 5.7 | 12.8 | 14 | 35 | 76 | ........ | 1.8 | 29.0 | ........ | 80 |
| 90 | 2.7 | 6.7 | 14.5 | 15 | 40 | 82 | ........ | 3.6 | 39.0 | ........ | 130 |
| 100 | 3.1 | 7.8 | 16.1 | 17 | 44 | 85 | ........ | 5.9 | 50.0 | 7 | 180 |
| 110 | 3.4 | 9.0 | 17.7 | 18 | 49 | 88 | ........ | 9.2 | 64.0 | 20 | 240 |
| 120 | 3.8 | 10.0 | 19.4 | 20 | 53 | 91 | ........ | 12.5 | 78.0 | 35 | 320 |
| 130 | 4.3 | 11.2 | 21.0 | 21 | 57 | 94 | ........ | 17.1 | 94.0 | 50 | 410 |
| 140 | 4.8 | 12.3 | 22.6 | 23 | 60 | 96 | ........ | 22.0 | 112.0 | 67 | 500 |
| 150 | 5.3 | 13.4 | 24.2 | 25 | 63 | 98 | 1.0 | 28.0 | 131.0 | 86 | 600 |
| 160 | 5.9 | 14.5 | 25.7 | 27 | 66 | 100 | 1.8 | 34.0 | 152.0 | 110 | 700 |
| 170 | 6.6 | 15.5 | 27.2 | 29 | 68 | 102 | 2.6 | 40.0 | 174.0 | 130 | 810 |
| 180 | 7.3 | 16.5 | ........ | 31 | 70 | ........ | 3.4 | 47.0 | ........ | 150 | 910 |
| 190 | 8.0 | 17.5 | ........ | 33 | 72 | ........ | 4.6 | 54.0 | ........ | 180 | 1,020 |
| 200 | 8.7 | 18.4 | ........ | 35 | 74 | ........ | 5.9 | 61.0 | ........ | 210 | 1,130 |

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[1] Based on measurements of 186 trees, 109 to 325 years old, made by S. J. Record in 1905.

TABLE 9.—*Growth of hemlock in the Southern Appalachian Mountains.*[1]

| Age. | Diameter breast-high—inches. | | | | | Height—feet. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | All types. | | Slope type. | | Cove type. | All types. | | Slope type. | | Cove type. |
| | | | West Virginia. | Tennessee. | North Carolina. | | | West Virginia. | Tennessee. | North Carolina. |
| | Minimum. | Maximum. | Average. | Average. | Average. | Minimum. | Maximum. | Average. | Average. | Average. |
| *Years.* | | | | | | | | | | |
| 20 | 0.1 | 4.0 | 0.4 | 0.2 | ........ | ........ | 29 | ........ | ........ | ........ |
| 30 | .7 | 6.7 | .9 | .9 | 1.1 | 9 | 41 | ........ | 9 | 15 |
| 40 | 1.2 | 9.0 | 1.3 | 1.9 | 2.2 | 11 | 53 | 11 | 16 | 23 |
| 50 | 1.8 | 11.2 | 1.9 | 3.0 | 3.4 | 14 | 63 | 14 | 23 | 30 |
| 60 | 2.3 | 13.1 | 2.4 | 4.1 | 4.7 | 16 | 71 | 17 | 30 | 36 |
| 70 | 2.8 | 15.0 | 2.9 | 5.3 | 6.2 | 19 | 79 | 20 | 37 | 42 |
| 80 | 3.3 | 16.9 | 3.6 | 6.7 | 7.6 | 21 | 86 | 24 | 44 | 47 |
| 90 | 3.8 | 18.8 | 4.2 | 8.0 | 9.1 | 23 | 92 | 27 | 51 | 53 |
| 100 | 4.3 | 20.6 | 4.9 | 9.4 | 10.5 | 25 | 98 | 31 | 58 | 58 |
| 110 | 4.8 | 22.5 | 5.6 | 10.7 | 11.9 | 28 | 103 | 34 | 64 | 62 |
| 120 | 5.2 | 24.3 | 6.4 | 11.8 | 13.2 | 30 | 107 | 39 | 69 | 66 |
| 130 | 5.6 | 26.2 | 7.3 | 12.9 | 14.5 | 32 | 111 | 43 | 73 | 70 |
| 140 | 6.0 | 28.0 | 8.1 | 14.0 | 15.5 | 34 | 114 | 47 | 77 | 73 |
| 150 | 6.4 | 30.0 | 8.9 | 15.1 | 16.5 | 35 | 117 | 51 | 81 | 76 |
| 160 | 6.8 | 31.9 | 9.9 | 16.1 | 17.4 | 37 | 120 | 56 | 84 | 78 |
| 170 | 7.2 | 33.8 | 10.9 | 17.1 | 18.3 | 39 | 122 | 60 | 87 | 81 |
| 180 | 7.6 | 35.7 | 11.9 | 18.1 | 19.2 | 41 | 125 | 64 | 90 | 83 |
| 190 | 8.0 | 37.5 | 12.7 | 19.1 | 20.0 | 43 | 127 | 67 | 93 | 85 |
| 200 | 8.3 | 39.5 | 13.5 | 20.0 | 20.7 | 44 | 129 | 70 | 95 | 87 |

| Age. | Volume—cubic feet. | | | | | Volume—board feet. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | All types. | | Slope type. | | Cove type. | All types. | Slope type. | | Cove type. |
| | | | West Virginia. | Tennessee. | North Carolina. | | West Virginia. | Tennessee. | North Carolina. |
| | Minimum. | Maximum. | Average. | Average. | Average. | Maximum. | Average. | Average. | Average. |
| *Years.* | | | | | | | | | |
| 20 | | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 30 | ........ | 3.8 | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 40 | ........ | 10.3 | ........ | ........ | ........ | 4 | ........ | ........ | ........ |
| 50 | ........ | 19.7 | ........ | ........ | ........ | 30 | ........ | ........ | ........ |
| 60 | ........ | 31.0 | ........ | ........ | ........ | 68 | ........ | ........ | ........ |
| 70 | ........ | 45.0 | ........ | 1.5 | 3.1 | 120 | ........ | ........ | ........ |
| 80 | ........ | 62.0 | ........ | 4.2 | 6.2 | 180 | ........ | ........ | ........ |
| 90 | ........ | 82.0 | ........ | 8.0 | 10.5 | 260 | ........ | ........ | ........ |
| 100 | ........ | 105.0 | ........ | 12.4 | 15.9 | 350 | ........ | ........ | 14 |
| 110 | ........ | 130.0 | 1.7 | 17.9 | 22.0 | 450 | ........ | 20 | 34 |
| 120 | 1.2 | 157.0 | 3.0 | 24.0 | 29.0 | 580 | ........ | 39 | 56 |
| 130 | 1.6 | 188.0 | 4.8 | 31.0 | 36.0 | 730 | ........ | 60 | 79 |
| 140 | 2.2 | 220.0 | 7.0 | 38.0 | 44.0 | 910 | ........ | 85 | 100 |
| 150 | 2.8 | 257.0 | 10.0 | 46.0 | 52.0 | 1,130 | ........ | 110 | 130 |
| 160 | 3.5 | 297.0 | 13.5 | 54.0 | 60.0 | 1,380 | 10 | 150 | 160 |
| 170 | 4.3 | 340.0 | 17.7 | 64.0 | 68.0 | 1,650 | 22 | 190 | 200 |
| 180 | 5.2 | 381.0 | 22.0 | 74.0 | 77.0 | 1,920 | 39 | 230 | 250 |
| 190 | 6.1 | 422.0 | 27.0 | 86.0 | 86.0 | 2,170 | 58 | 270 | 300 |
| 200 | 7.1 | 460.0 | 32.0 | 98.0 | 94.0 | 2,400 | 80 | 310 | 350 |

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[1] Based on the following data, collected by Walter Mulford, 1905–1906:

| | |
|---|---|
| West Virginia, Greenbrier County | 47 trees, 137 to 200 years old. |
| Tennessee, Johnson County | 131 trees, 111 to 200 years old. |
| North Carolina, Mitchell County | 308 trees, 89 to 200 years old. |

TABLE 10.—*Growth of hemlock in Otsego County, N. Y.*[1]

| Age. | Diameter breast-high. | | | Height. | | | Volume. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Inches. | | | Feet. | | | Cubic feet. | | Board feet. | |
| | Minimum. | Average. | Maximum. | Minimum. | Average. | Maximum. | Average. | Maximum. | Average. | Maximum. |
| *Years.* | | | | | | | | | | |
| 20 | ........ | 0.4 | 1.5 | ........ | 7 | 17 | ........ | ........ | ........ | ........ |
| 30 | 0.1 | .9 | 2.9 | 5 | 10 | 28 | ........ | ........ | ........ | ........ |
| 40 | .3 | 1.4 | 4.4 | 6 | 13 | 39 | ........ | ........ | ........ | ........ |
| 50 | .5 | 1.9 | 5.9 | 7 | 16 | 49 | ........ | 2.8 | ........ | ........ |
| 60 | .7 | 2.5 | 7.4 | 8 | 20 | 58 | ........ | 6.4 | ........ | ........ |
| 70 | .9 | 3.3 | 8.9 | 9 | 24 | 66 | ........ | 11.4 | ........ | 30 |
| 80 | 1.1 | 4.0 | 10.5 | 10 | 28 | 73 | ........ | 18.1 | ........ | 55 |
| 90 | 1.3 | 4.7 | 12.1 | 11 | 32 | 79 | ........ | 26.0 | ........ | 86 |
| 100 | 1.5 | 5.5 | 13.8 | 13 | 36 | 84 | 1.7 | 36.0 | ........ | 120 |
| 110 | 1.9 | 6.4 | 15.4 | 15 | 40 | 88 | 3.1 | 47.0 | ........ | 170 |
| 120 | 2.1 | 7.3 | 17.1 | 16 | 45 | 91 | 5.0 | 60.0 | ........ | 230 |
| 130 | 2.4 | 8.3 | 18.7 | 17 | 50 | 94 | 7.9 | 75.0 | 16 | 300 |
| 140 | 2.7 | 9.4 | 20.4 | 19 | 54 | 97 | 11.1 | 91.0 | 29 | 380 |
| 150 | 3.0 | 10.5 | 22.1 | 20 | 59 | 100 | 15.5 | 108.0 | 44 | 480 |
| 160 | 3.3 | 11.6 | 23.9 | 22 | 63 | 102 | 20.0 | 126.0 | 61 | 590 |
| 170 | 3.7 | 12.7 | 25.7 | 23 | 66 | 105 | 24.0 | 145.0 | 80 | 710 |
| 180 | 4.1 | 13.5 | 27.4 | 25 | 69 | ........ | 29.0 | ........ | 100 | 850 |
| 190 | 4.4 | 14.3 | 29.1 | 27 | 71 | ........ | 34.0 | ........ | 120 | 1,000 |
| 200 | 4.9 | 15.1 | 30.9 | 29 | 72 | ........ | 39.0 | ........ | 140 | 1,150 |

[1] Based on measurements of 176 trees, 48 to 420 years old, made by J. G. Peters in 1902.

TABLE 11.—*Growth of hemlock in Vermont.*[2]

(Average.)

| Age. | Diameter breast-high. | Volume. |
|---|---|---|
| *Years.* | *Inches.* | *Bd. ft.* |
| 130 | 7.0 | ........... |
| 140 | 8.0 | 34 |
| 150 | 9.0 | 48 |
| 160 | 10.2 | 69 |
| 170 | 11.4 | 100 |
| 180 | 12.6 | 140 |
| 190 | 13.9 | 180 |
| 200 | 15.2 | 230 |

[2] Data contained in Vermont Experiment Station Bulletin 161, "Hemlock in Vermont," by A. F. Hawes. Volumes scaled by Vermont rule.

## SUSCEPTIBILITY TO INJURY.

As before stated, hemlock is extremely sensitive to sudden changes in the density of the forest. Middle-aged and full-grown trees appear to be the most susceptible.

The most destructive of the insect enemies of hemlock is the flat-headed eastern hemlock bark borer, *Melanophila fulvoguttata* Harr. According to Mr. H. E. Burke[3] this insect "has caused the death of a large amount of hemlock timber throughout the Appalachian and Northeastern States. It mines the bark on living, injured, and dying trees and kills them outright or hastens their death." Whenever large quantities of hemlock are found to be dying, search should be made for the work of this insect, and, if found, special advice in regard to combating it should be obtained from the Bureau of Entomology, Division of Forest Insects.

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[3] "Injuries to forest trees by flat-headed borers." Yearbook of the Department of Agriculture, 1909; pp. 405–406. See also following articles by Dr. A. D. Hopkins:

"Catalogue of exhibits of insect enemies of forest and forest products, etc.," Bul. 48, Bureau of Entomology, U. S. Department of Agriculture, 1904, p. 38.

"On the study of forest entomology in America," Bul. 37, Bureau of Entomology, 1902, p. 22.

Hemlock is comparatively free from serious parasitic fungous diseases. Damping-off, the great enemy of many conifers in the seedling stage, is almost unknown with this species. While there are several diseases of the living tree, they seem never to occur in serious epidemics. This is no doubt largely due to the fact that the tree usually grows in mixed stands. The timber when cut is very susceptible to decay, and a large number of saprophytic fungi attack it.[1]

The shallow-rootedness of hemlock makes it very susceptible to fire. A ground fire which burns through the humus will usually kill hemlock trees, though deeper-rooted species may escape with slight injury. Even a severe surface fire may dry out the humus or damage the roots sufficiently to kill the tree outright, or at least to lay it open to attack by fungi and insects. Severe crown fires are invariably fatal. Fires of all kinds are most to be feared after logging operations in adjacent timber, when the ground is covered with the dry and highly inflammable tree tops and branches. The best safeguard is to burn this débris under conditions making it impossible for the fire to escape. The danger can be lessened by lopping away all branches from the tops, and either piling them or scattering them close to the ground.

Because of its relatively short, stout, tapering trunk, hemlock is less subject to windfall than its shallow root system would lead one to expect. Where it grows as an understory among taller neighbors it is rarely thrown except by winds strong enough to overthrow all species alike. Severe damage is often done, however, to stands consisting principally of hemlock, especially when located on shallow soil and in situations exposed to the wind. In September, 1896, a heavy storm near Wilkes-Barre, Pa., blew down over 6,000,000 feet of hemlock in one tract, and similar cases are not uncommon. Where the roots are fairly secure, the trunk or the crown may be snapped off by severe winds.

The most common and in the aggregate the worst injury to hemlock from wind is the so-called "wind-shake," which is a separation of the rings of wood caused by the tree being rocked back and forth. Wind-shake is always found in the butt, which is thereby rendered

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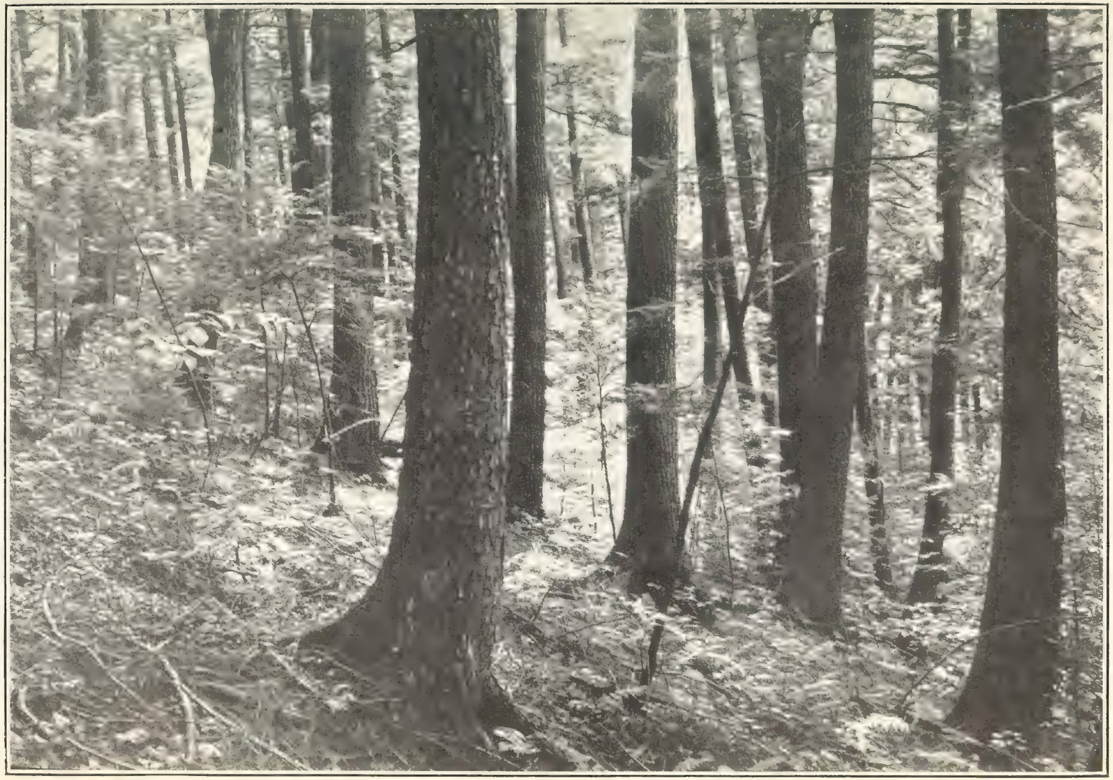
[1] This paragraph regarding diseases was prepared by Perley Spaulding, pathologist, Investigations in Forest Pathology, Bureau of Plant Industry. Further information on fungous injury to hemlock is contained in "Diseases of the eastern hemlock," by Dr. Spaulding, in Proc. Society of American Foresters Vol. IX, No. 2, pp. 245–256.



SUPPRESSED HEMLOCK SAPLINGS IN A MATURE STAND OF HEMLOCK.

These will fill openings left by the removal of old trees, but too sudden an opening of the stand will kill them.

unfit for lumber. In connection with the prevailing "butt rot," this has made necessary the custom of cutting high stumps and sawing off the butts until they reveal solid wood. Where there is a market for pulpwood, high stumps and butts left in the woods represent a great deal of unnecessary waste.

## HEMLOCK IN FOREST MANAGEMENT.

Hemlock grows too slowly and is of too little commercial value to be recommended for planting or for encouragement among natural second growth as a timber tree. An understory of hemlock, however, like one of spruce or fir, is useful for soil protection, especially in stands of oak, chestnut, pine, and other species, when these do not themselves cast a sufficiently heavy shade. As a decorative tree for parks it is very desirable, and its heavy foliage and shade endurance give it exceptional value for the protection of stream sources.

The management of hemlock will ultimately be restricted to lands useless not only for agriculture but also for growing many kinds of commercial timber. Poorly accessible mountain lands, where logging is difficult and expensive, can well be devoted to raising hemlock and other slow-growing timber through long rotations and to large sizes. The expense entailed by such a procedure, however, will ordinarily be too great to warrant private investment, and the management will therefore be a State problem. In such places lumber production will tend to become secondary to protection as an object of management.

Hemlock's tolerance of shade adapts it for growth as a subordinate stand among other kinds of timber. In such cases it materially increases the yield per acre and at the same time protects and enriches the forest soil, thereby tending to accelerate the growth of the other species.

To increase the proportion and accelerate the growth of hemlock in the mixed stands where it is now found, the selection ("single-tree") method of management is best. This involves the removal at stated intervals of scattered mature trees or small groups of trees, and should not open up the stand enough to endanger it from windfall or from too sudden access of light and air. On steep slopes the cutting must be especially light, to prevent erosion. Besides accelerating the growth of the hemlock understory by admitting light, the system also insures a constant growth of timber without the long, unproductive period of reestablishment which follows clear cutting. In all selection cutting the branches should be lopped and scattered.

Pure or nearly pure hemlock second growth should be thinned very lightly and often, so as to insure to each tree a good supply of light and growing space. Additional thinnings should be made whenever the crowns close together.

A great deal of the remaining old-growth hemlock timber occupies fertile soil, suitable either for agriculture or for raising timber crops of rapid-growing species. The expense of selection cuttings to favor hemlock on lands of this quality is not warranted. Clear cutting, therefore, is the best in such cases. Attempts to secure hemlock reproduction in the ensuing second growth, however, are obviously out of place. Unless the land is claimed for cultivation, some of the more rapid growing species which appear in the second growth are usually of more promise as the principal crop.

The management of hemlock on level lands thus becomes a problem of the best use of the existing timber, with no special effort to secure hemlock reproduction. What constitutes best use is determined by market and labor conditions in any given region. The utilization of all species constantly becomes more intensive, and the premium once placed on waste both in the woods and at the mill is growing less as new uses are introduced and the value of wood increases. Paper-pulp and fiber-board manufacture has presented good opportunities for profitably disposing of waste. In some regions hemlock is going into pulp instead of lumber. It is in connection with pulpwood logging that tanbark gathering can be done most economically, since peeled logs are more suitable for pulp and less suitable for lumber than unpeeled. The use of hemlock for pulp has the further advantage that it includes crooked and small logs of little or no value for lumber and of knotty tops and broken and defective logs that would otherwise be left in the woods to rot. Quantities of hemlock slabs are now sold to pulp mills by sawmills; but much low-grade hemlock lumber is still produced, the value of which is often less than that of an equal wood volume made into pulp. Among the economies of the future one of the most important will be a closer discrimination between logs and portions of logs which will make high-grade lumber and those which will pay better for pulp.

# APPENDIX.

Tables 12 to 15 show the volumes of average hemlock trees, in board feet, Scribner rule, in the Lake States and the Southern Appalachian region. These are based both on the total height of the tree and on the number of logs. Table 16 gives both the cubic-foot and the board-foot volumes (by actual measurement, not by log scale) of small-sized hemlock in northern New Hampshire. Table 17 gives the merchantable cubic volume of hemlock (including bark) in the Lake States. Cubic volumes may be reduced roughly to cords by dividing by 90. The volume without bark can be obtained approximately by deducting 19 per cent from the total volume for Lake States figures and the following per cents for Southern Appalachian measurements:

| Diameter breast-high. | Bark volume in proportion to total volume |
|---|---|
| *Inches.* | *Per cent.* |
| 6– 9 | 15 |
| 10–15 | 17 |
| 16–21 | 18 |
| 22–27 | 19 |

TABLE 12.—*Volume of hemlock, in board feet, Wisconsin (Marinette and Vilas Counties) and Michigan (Gogebic County).*

[Based on total height of tree. Scaled by the Scribner rule.]

| Diameter breast-high. | Height of tree—feet. | | | | | | | | Diameter inside bark of top. | Basis. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | | |
| | Volume—board feet. | | | | | | | | | |
| *Inches.* | | | | | | | | | *Inches.* | *Trees.* |
| 8 | 5 | 7 | 13 | 20 | 25 | 30 | ...... | ...... | 6 | 53 |
| 9 | 8 | 14 | 22 | 29 | 35 | 40 | ...... | ...... | 6 | 72 |
| 10 | 12 | 22 | 32 | 40 | 47 | 52 | ...... | ...... | 6 | 56 |
| 11 | 16 | 29 | 42 | 51 | 60 | 67 | 75 | ...... | 6 | 53 |
| 12 | 20 | 37 | 53 | 64 | 76 | 84 | 93 | ...... | 7 | 46 |
| 13 | 25 | 46 | 65 | 78 | 94 | 100 | 110 | ...... | 7 | 35 |
| 14 | 30 | 56 | 77 | 95 | 110 | 130 | 140 | ...... | 7 | 18 |
| 15 | 36 | 65 | 90 | 110 | 130 | 150 | 160 | ...... | 8 | 31 |
| 16 | 41 | 76 | 110 | 130 | 160 | 180 | 190 | 200 | 8 | 25 |
| 17 | ...... | 87 | 120 | 150 | 180 | 210 | 220 | 240 | 8 | 30 |
| 18 | ...... | 100 | 140 | 180 | 210 | 240 | 260 | 280 | 8 | 14 |
| 19 | ...... | ...... | 160 | 200 | 240 | 280 | 300 | 320 | 9 | 16 |
| 20 | ...... | ...... | 180 | 230 | 280 | 310 | 340 | 360 | 9 | 20 |
| 21 | ...... | ...... | 200 | 260 | 310 | 350 | 380 | 410 | 9 | 11 |
| 22 | ...... | ...... | 220 | 290 | 350 | 390 | 430 | 470 | 10 | 13 |
| 23 | ...... | ...... | ...... | 330 | 380 | 440 | 480 | 520 | 10 | 4 |
| 24 | ...... | ...... | ...... | 360 | 420 | 490 | 540 | 580 | 10 | 6 |
| 25 | ...... | ...... | ...... | 390 | 460 | 530 | 600 | 650 | 10 | 9 |
| 26 | ...... | ...... | ...... | 430 | 510 | 580 | 660 | 720 | 11 | 4 |
| 27 | ...... | ...... | ...... | 470 | 550 | 640 | 720 | 790 | 11 | 8 |
| 28 | ...... | ...... | ...... | 500 | 590 | 690 | 780 | 870 | 11 | 6 |
| 29 | ...... | ...... | ...... | 540 | 640 | 750 | 850 | 940 | 11 | 3 |
| 30 | ...... | ...... | ...... | 570 | 680 | 800 | 920 | 1,030 | 12 | 1 |

TABLE 12.—*Volume of hemlock, in board feet, Wisconsin* (*Marinette and Vilas Counties*) *and Michigan* (*Gogebic County*)—Continued.

| Diameter breast-high. | Height of tree—feet. | | | | | | | | Diameter inside bark of top. | Basis. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | | |
| | Volume—board feet. | | | | | | | | | |
| *Inches.* | | | | | | | | | *Inches.* | *Trees.* |
| 31 | ...... | ...... | ...... | ...... | 720 | 860 | 990 | 1,110 | 12 | 2 |
| 32 | ...... | ...... | ...... | ...... | 760 | 930 | 1,070 | 1,200 | 12 | 1 |
| 33 | ...... | ...... | ...... | ...... | 810 | 990 | 1,140 | 1,290 | 12 | 3 |
| 34 | ...... | ...... | ...... | ...... | 850 | 1,050 | 1,220 | 1,380 | 13 | 1 |
| 35 | ...... | ...... | ...... | ...... | ...... | 1,120 | 1,300 | 1,480 | 13 | 1 |
| 36 | ...... | ...... | ...... | ...... | ...... | 1,180 | 1,380 | 1,570 | 13 | ...... |
| 37 | ...... | ...... | ...... | ...... | ...... | ...... | 1,470 | 1,670 | 13 | ...... |
| 38 | ...... | ...... | ...... | ...... | ...... | ...... | 1,550 | 1,780 | 14 | ...... |
| | | | | | | | | | | 542 |

Scaled from taper curves, mostly in 16.3-foot logs, with a few shorter logs. Stump height, 2 feet.

TABLE 13.—*Volume of hemlock, in board feet, Wisconsin* (*Marinette and Vilas Counties*) *and Michigan* (*Gogebic County*).

[Based on number of 16-foot logs per tree. Scaled by the Scribner rule.]

| Diameter breast-high. | Number of 16-foot logs. | | | | | | | | | Diameter inside bark of top. | Basis. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 | | |
| | Volume—board feet. | | | | | | | | | | |
| *Inches.* | | | | | | | | | | *Inches.* | *Trees.* |
| 8 | 18 | 28 | 38 | ...... | ...... | ...... | ...... | ...... | ...... | 6 | 53 |
| 9 | 19 | 30 | 42 | ...... | ...... | ...... | ...... | ...... | ...... | 6 | 72 |
| 10 | 20 | 32 | 47 | 60 | ...... | ...... | ...... | ...... | ...... | 6 | 56 |
| 11 | 23 | 39 | 57 | 72 | ...... | ...... | ...... | ...... | ...... | 6 | 53 |
| 12 | 25 | 45 | 66 | 86 | 110 | ...... | ...... | ...... | ...... | 7 | 46 |
| 13 | 26 | 53 | 79 | 100 | 130 | ...... | ...... | ...... | ...... | 7 | 35 |
| 14 | 28 | 63 | 92 | 120 | 140 | 170 | ...... | ...... | ...... | 7 | 18 |
| 15 | 30 | 72 | 110 | 130 | 170 | 200 | ...... | ...... | ...... | 8 | 31 |
| 16 | 32 | 82 | 120 | 150 | 190 | 220 | ...... | ...... | ...... | 8 | 25 |
| 17 | 34 | 94 | 140 | 180 | 210 | 250 | ...... | ...... | ...... | 8 | 30 |
| 18 | 36 | 110 | 160 | 200 | 240 | 280 | 320 | ...... | ...... | 8 | 14 |
| 19 | 38 | 120 | 180 | 220 | 270 | 310 | 350 | ...... | ...... | 9 | 16 |
| 20 | 40 | 130 | 200 | 250 | 290 | 340 | 390 | ...... | ...... | 9 | 20 |
| 21 | ...... | 150 | 230 | 280 | 330 | 380 | 430 | ...... | ...... | 9 | 11 |
| 22 | ...... | 170 | 260 | 310 | 360 | 420 | 480 | 530 | ...... | 10 | 13 |
| 23 | ...... | ...... | 280 | 340 | 400 | 460 | 530 | 600 | ...... | 10 | 4 |
| 24 | ...... | ...... | 310 | 370 | 440 | 510 | 580 | 660 | ...... | 10 | 6 |
| 25 | ...... | ...... | 330 | 400 | 480 | 560 | 640 | 730 | ...... | 10 | 9 |
| 26 | ...... | ...... | 360 | 430 | 520 | 600 | 700 | 810 | 920 | 11 | 4 |
| 27 | ...... | ...... | ...... | 470 | 560 | 660 | 770 | 880 | 1,000 | 11 | 8 |
| 28 | ...... | ...... | ...... | 500 | 600 | 710 | 830 | 960 | 1,090 | 11 | 6 |
| 29 | ...... | ...... | ...... | 530 | 640 | 760 | 900 | 1,040 | 1,180 | 11 | 3 |
| 30 | ...... | ...... | ...... | 560 | 680 | 820 | 960 | 1,110 | 1,270 | 12 | 1 |
| 31 | ...... | ...... | ...... | ...... | 720 | 880 | 1,040 | 1,200 | 1,370 | 12 | 2 |
| 32 | ...... | ...... | ...... | ...... | 770 | 930 | 1,110 | 1,280 | 1,460 | 12 | 1 |
| 33 | ...... | ...... | ...... | ...... | 820 | 990 | 1,180 | 1,370 | 1,560 | 12 | 3 |
| 34 | ...... | ...... | ...... | ...... | 870 | 1,050 | 1,250 | 1,450 | 1,670 | 13 | 1 |
| 35 | ...... | ...... | ...... | ...... | ...... | 1,140 | 1,340 | 1,550 | 1,760 | 13 | 1 |
| 36 | ...... | ...... | ...... | ...... | ...... | 1,210 | 1,420 | 1,640 | 1,870 | 13 | ...... |
| 37 | ...... | ...... | ...... | ...... | ...... | 1,270 | 1,500 | 1,730 | 1,970 | 13 | ...... |
| 38 | ...... | ...... | ...... | ...... | ...... | 1,330 | 1,580 | 1,830 | 2,080 | 14 | ...... |
| | | | | | | | | | | | 542 |

Scaled from taper curves, mostly in 16.3-foot logs, with a few shorter logs. Stump height, 2 feet.

TABLE 14.—*Volume of hemlock in board feet, Southern Appalachian region.*[1]

[Based on total height of trees. Scaled by Scribner Decimal C rule.]

| Diameter breast-high. | Height of tree—feet. | | | | | | | | Height of stump. | Diameter inside bark of top. | Total basis. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 50 | 60 | 70 | 80 | 90 | 100 | 110 | 120 | | | |
| | Volume—board feet (in tens). | | | | | | | | | | |
| *Inches.* | | | | | | | | | *Feet.* | *Inches.* | *Trees.* |
| 10 | 1 | 1 | 2 | ...... | ...... | ...... | ...... | ...... | 2.1 | 7 | 6 |
| 11 | 2 | 2 | 3 | 3 | ...... | ...... | ...... | ...... | 2.2 | 8 | 3 |
| 12 | 3 | 4 | 4 | 5 | 5 | ...... | ...... | ...... | 2.2 | 8 | 9 |
| 13 | 4 | 5 | 6 | 7 | 8 | ...... | ...... | ...... | 2.3 | 9 | 23 |
| 14 | 6 | 7 | 8 | 9 | 10 | 12 | ...... | ...... | 2.3 | 9 | 33 |
| 15 | 7 | 8 | 9 | 11 | 13 | 16 | ...... | ...... | 2.4 | 10 | 59 |
| 16 | 9 | 10 | 11 | 13 | 16 | 19 | 24 | ...... | 2.4 | 10 | 64 |
| 17 | 10 | 12 | 14 | 16 | 19 | 23 | 28 | ...... | 2.4 | 11 | 65 |
| 18 | 12 | 14 | 17 | 20 | 23 | 27 | 32 | ...... | 2.5 | 11 | 77 |
| 19 | 14 | 17 | 20 | 23 | 27 | 31 | 36 | 41 | 2.5 | 12 | 83 |
| 20 | 17 | 20 | 23 | 26 | 31 | 35 | 41 | 46 | 2.5 | 12 | 68 |
| 21 | 19 | 23 | 26 | 30 | 35 | 40 | 46 | 51 | 2.5 | 13 | 80 |
| 22 | 22 | 26 | 30 | 34 | 40 | 45 | 51 | 57 | 2.6 | 13 | 81 |
| 23 | 25 | 29 | 34 | 39 | 44 | 50 | 56 | 63 | 2.6 | 13 | 86 |
| 24 | 29 | 33 | 39 | 44 | 50 | 56 | 62 | 69 | 2.6 | 14 | 67 |
| 25 | ...... | 38 | 43 | 49 | 55 | 62 | 69 | 76 | 2.6 | 14 | 81 |
| 26 | ...... | 42 | 48 | 54 | 61 | 68 | 75 | 83 | 2.6 | 15 | 62 |
| 27 | ...... | 47 | 53 | 60 | 67 | 74 | 83 | 91 | 2.6 | 15 | 64 |
| 28 | ...... | 52 | 59 | 66 | 73 | 81 | 90 | 99 | 2.6 | 15 | 67 |
| 29 | ...... | 58 | 64 | 72 | 80 | 89 | 98 | 108 | 2.6 | 16 | 54 |
| 30 | ...... | 63 | 70 | 78 | 87 | 97 | 107 | 117 | 2.6 | 16 | 34 |
| 31 | ...... | ...... | 76 | 85 | 95 | 105 | 116 | 127 | 2.7 | 17 | 33 |
| 32 | ...... | ...... | 82 | 92 | 102 | 114 | 126 | 138 | 2.7 | 17 | 37 |
| 33 | ...... | ...... | 88 | 99 | 111 | 124 | 136 | 150 | 2.7 | 18 | 29 |
| 34 | ...... | ...... | 94 | 106 | 120 | 134 | 147 | 162 | 2.7 | 18 | 33 |
| 35 | ...... | ...... | 100 | 114 | 129 | 144 | 158 | 174 | 2.7 | 19 | 19 |
| 36 | ...... | ...... | ...... | 122 | 138 | 154 | 170 | 187 | 2.7 | 19 | 21 |
| 37 | ...... | ...... | ...... | 131 | 148 | 165 | 182 | 200 | 2.7 | 19 | 9 |
| 38 | ...... | ...... | ...... | 140 | 158 | 176 | 194 | 212 | 2.7 | 20 | 10 |
| 39 | ...... | ...... | ...... | 149 | 168 | 187 | 206 | 225 | 2.8 | 20 | 8 |
| 40 | ...... | ...... | ...... | 158 | 179 | 198 | 218 | 238 | 2.8 | 21 | 7 |
| 41 | ...... | ...... | ...... | ...... | 189 | 209 | 230 | 251 | 2.8 | 21 | 5 |
| 42 | ...... | ...... | ...... | ...... | 199 | 220 | 242 | 264 | 2.8 | 22 | 5 |
| 43 | ...... | ...... | ...... | ...... | 209 | 232 | 254 | 277 | 2.8 | 22 | 6 |
| 44 | ...... | ...... | ...... | ...... | 220 | 244 | 267 | 290 | 2.8 | 23 | 4 |
| 45 | ...... | ...... | ...... | ...... | 230 | 255 | 279 | 303 | 2.8 | 23 | 3 |
| 46 | ...... | ...... | ...... | ...... | ...... | 266 | 291 | 316 | 2.8 | 24 | 1 |
| 47 | ...... | ...... | ...... | ...... | ...... | 278 | 303 | 329 | 2.8 | 25 | 1 |
| 48 | ...... | ...... | ...... | ...... | ...... | 289 | 315 | 342 | 2.9 | 25 | 2 |
| 49 | ...... | ...... | ...... | ...... | ...... | 301 | 327 | 355 | 2.9 | 26 | 1 |
| 50 | ...... | ...... | ...... | ...... | ...... | 312 | 340 | 368 | 2.9 | 26 | 2 |
| | | | | | | | | | | | 1,402 |

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[1] From data secured under the direction of Walter Mulford, 1905–6.

TABLE 15.—*Volume of hemlock in board feet, Southern Appalachion region.*[1]

[Based on number of 16-foot logs per tree. Scaled by Scribner rule.]

| Diameter breast-high. | Number of 16-foot logs. | | | | | | | | | | | | | Diameter inside bark of top. | Basis. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 1½ | 2 | 2½ | 3 | 3½ | 4 | 4½ | 5 | 5½ | 6 | 6½ | 7 | | |
| | Volume—board feet. | | | | | | | | | | | | | | |
| *Inches.* | | | | | | | | | | | | | | *Inches.* | *Trees.* |
| 8 | 18 | 29 | 40 | 52 | 63 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 6 | 17 |
| 9 | 20 | 33 | 46 | 61 | 74 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 6 | 17 |
| 10 | 22 | 38 | 53 | 71 | 87 | 100 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 6 | 19 |
| 11 | 24 | 44 | 64 | 84 | 100 | 120 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 6 | 7 |
| 12 | 25 | 50 | 72 | 97 | 120 | 140 | 170 | ...... | ...... | ...... | ...... | ...... | ...... | 7 | 15 |
| 13 | 26 | 58 | 86 | 110 | 140 | 170 | 190 | ...... | ...... | ...... | ...... | ...... | ...... | 7 | 29 |
| 14 | 28 | 64 | 98 | 130 | 160 | 190 | 220 | ...... | ...... | ...... | ...... | ...... | ...... | 7 | 35 |
| 15 | 30 | 73 | 110 | 150 | 180 | 220 | 250 | ...... | ...... | ...... | ...... | ...... | ...... | 8 | 62 |
| 16 | 32 | 83 | 130 | 170 | 210 | 250 | 280 | 310 | ...... | ...... | ...... | ...... | ...... | 8 | 71 |
| 17 | 34 | 95 | 150 | 190 | 240 | 280 | 320 | 360 | ...... | ...... | ...... | ...... | ...... | 8 | 74 |
| 18 | 37 | 110 | 160 | 210 | 260 | 310 | 350 | 400 | ...... | ...... | ...... | ...... | ...... | 8 | 71 |
| 19 | 40 | 120 | 180 | 240 | 290 | 340 | 400 | 450 | ...... | ...... | ...... | ...... | ...... | 9 | 82 |
| 20 | 43 | 130 | 200 | 260 | 320 | 380 | 440 | 500 | 550 | ...... | ...... | ...... | ...... | 9 | 72 |
| 21 | 46 | 140 | 230 | 290 | 360 | 420 | 490 | 550 | 610 | ...... | ...... | ...... | ...... | 9 | 79 |
| 22 | 50 | 160 | 250 | 320 | 400 | 470 | 530 | 610 | 680 | ...... | ...... | ...... | ...... | 10 | 77 |
| 23 | 54 | 180 | 280 | 360 | 440 | 510 | 590 | 660 | 740 | ...... | ...... | ...... | ...... | 10 | 82 |
| 24 | 58 | 200 | 310 | 400 | 480 | 560 | 650 | 730 | 810 | 890 | ...... | ...... | ...... | 10 | 70 |
| 25 | 61 | 220 | 340 | 430 | 530 | 620 | 700 | 790 | 880 | 970 | ...... | ...... | ...... | 10 | 73 |
| 26 | 65 | 240 | 370 | 470 | 570 | 670 | 770 | 870 | 980 | 1,080 | 1,190 | ...... | ...... | 11 | 59 |
| 27 | 69 | 250 | 400 | 510 | 620 | 720 | 830 | 930 | 1,050 | 1,170 | 1,300 | ...... | ...... | 11 | 66 |
| 28 | 73 | 280 | 440 | 560 | 670 | 780 | 890 | 1,010 | 1,130 | 1,270 | 1,410 | 1.550 | ...... | 11 | 56 |
| 29 | 77 | 310 | 480 | 600 | 720 | 840 | 960 | 1,090 | 1,230 | 1,370 | 1,510 | 1,660 | ...... | 11 | 46 |
| 30 | 80 | 330 | 510 | 640 | 770 | 900 | 1,030 | 1,170 | 1,320 | 1,470 | 1,630 | 1,790 | 1,950 | 12 | 26 |
| 31 | .... | 360 | 550 | 690 | 820 | 960 | 1,100 | 1,260 | 1,420 | 1,580 | 1,750 | 1,910 | 2,070 | 12 | 34 |
| 32 | .... | 380 | 590 | 740 | 880 | 1,030 | 1,180 | 1,350 | 1,520 | 1,700 | 1,870 | 2,060 | 2,240 | 12 | 29 |
| 33 | .... | ..... | 630 | 780 | 930 | 1,090 | 1,260 | 1,440 | 1,630 | 1,820 | 2,010 | 2,200 | 2,390 | 12 | 14 |
| 34 | .... | ..... | 660 | 830 | 990 | 1,160 | 1,340 | 1,530 | 1,730 | 1,930 | 2,150 | 2,360 | 2,580 | 13 | 25 |
| 35 | .... | ..... | ..... | 880 | 1,050 | 1,230 | 1,420 | 1,630 | 1,840 | 2,050 | 2,270 | 2,490 | 2,710 | 13 | 19 |
| 36 | .... | ..... | ..... | 930 | 1,110 | 1,300 | 1,500 | 1,710 | 1,940 | 2,170 | 2,410 | 2,650 | 2,890 | 13 | 12 |
| 37 | .... | ..... | ..... | ..... | 1,160 | 1,360 | 1,580 | 1,820 | 2,060 | 2,300 | 2,560 | 2,820 | 3,090 | 13 | 4 |
| 38 | .... | ..... | ..... | ..... | 1,210 | 1,430 | 1,670 | 1,910 | 2,160 | 2,420 | 2,700 | 2,960 | 3,250 | 14 | 9 |
| 39 | .... | ..... | ..... | ..... | ...... | 1,500 | 1,750 | 2,010 | 2,280 | 2,560 | 2,840 | 3,130 | 3.410 | 14 | 3 |
| 40 | .... | ..... | ..... | ..... | ...... | 1,570 | 1,840 | 2,120 | 2,400 | 2,690 | 2,980 | 3,270 | 3,550 | 14 | 3 |
| 41 | .... | ..... | ..... | ..... | ...... | 1,650 | 1,930 | 2,230 | 2,520 | 2,820 | 3,120 | 3.420 | 3,720 | 14 | 2 |
| 42 | .... | ..... | ..... | ..... | ...... | 1,710 | 2,020 | 2,320 | 2,640 | 2,960 | 3,280 | 3,600 | 3,930 | 15 | 2 |
| 43 | .... | ..... | ..... | ..... | ...... | ...... | 2,110 | 2,430 | 2,760 | 3,100 | 3.440 | 3,770 | 4,100 | 15 | 4 |
| 44 | .... | ..... | ..... | ..... | ...... | ...... | 2,200 | 2,540 | 2,900 | 3,250 | 3,600 | 3,960 | 4,310 | 15 | ....... |
| 45 | .... | ..... | ..... | ..... | ...... | ...... | 2,300 | 2,660 | 3,030 | 3,400 | 3,760 | 4,140 | 4,510 | 15 | 1 |
| 46 | .... | ..... | ..... | ..... | ...... | ...... | 2,400 | 2,780 | 3,170 | 3,550 | 3,940 | 4,330 | 4,720 | 16 | 1 |
| 47 | .... | ..... | ..... | ..... | ...... | ...... | ...... | 2,920 | 3,310 | 3,710 | 4,110 | 4,520 | 4,940 | 16 | 1 |
| 48 | .... | ..... | ..... | ..... | ...... | ...... | ...... | 3,050 | 3,450 | 3,880 | 4,300 | 4,730 | 5,150 | 16 | 1 |
| 49 | .... | ..... | ..... | ..... | ...... | ...... | ...... | 3,200 | 3,600 | 4,030 | 4,480 | 4,930 | 5,360 | 16 | ....... |
| 50 | .... | ..... | ..... | ..... | ...... | ...... | ...... | 3,320 | 3,750 | 4,200 | 4,670 | 5,140 | 5.630 | 17 | 1 |
| | | | | | | | | | | | | | | | 1,370 |

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[1] From data secured under the direction of Walter Mulford, 1905–6.

TABLE 16.—*Volume of hemlock in cubic feet and board feet, southern New Hampshire.*

[Based on total height of tree.[1]]

| Diameter breast-high. | Height of tree—feet. | | | | | | | | | | Number of board feet per 1 cubic foot of log. | Diameter inside bark of last log. | Basis. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 | | 40 | | 50 | | 60 | | 70 | | | | |
| | Volume of used length. | | | | | | | | | | | | |
| *Inches.* | *Cu.ft.* | *Bd.ft.* | *Cu.ft.* | *Bd.ft.* | *Cu.ft.* | *Bd.ft.* | *Cu.ft.* | *Bd.ft.* | *Cu.ft.* | *Bd.ft.* | | *Inches.* | *Trees.* |
| 6 | 1.8 | 5 | 2.8 | ...... | 3.7 | ...... | ...... | ...... | ...... | ...... | 4.5 | 4.4 | 4 |
| 7 | 2.7 | 10 | 3.8 | 20 | 5.0 | 30 | 6.3 | 42 | ...... | ...... | 5.0 | 4.4 | 17 |
| 8 | 3.9 | 17 | 5.0 | 28 | 6.6 | 39 | 8.1 | 50 | ...... | ...... | 5.3 | 5.1 | 40 |
| 9 | 5.0 | 26 | 6.5 | 36 | 8.4 | 49 | 10.0 | 60 | 11.8 | ...... | 5.5 | 5.3 | 57 |
| 10 | 6.4 | 36 | 8.5 | 46 | 10.6 | 59 | 12.5 | 71 | 14.3 | 86 | 5.6 | 5.7 | 57 |
| 11 | 8.0 | 47 | 10.5 | 58 | 13.0 | 72 | 15.2 | 86 | 17.3 | 103 | 5.6 | 5.5 | 41 |
| 12 | 10.2 | 60 | 12.8 | 72 | 15.4 | 86 | 18.2 | 103 | 20.8 | 123 | 5.7 | 6.0 | 42 |
| 13 | 12.2 | ...... | 15.2 | 88 | 18.3 | 104 | 21.5 | 124 | 24.3 | 148 | 5.7 | 6.7 | 17 |
| 14 | ...... | ...... | 17.7 | 107 | 21.2 | 125 | 25.0 | 147 | 28.2 | 173 | 5.8 | 6.1 | 14 |
| 15 | ...... | ...... | 20.0 | 126 | 24.4 | 148 | 28.8 | 172 | 32.8 | 204 | 5.9 | 6.4 | 14 |
| 16 | ...... | ...... | 22.5 | 148 | 27.6 | 171 | 33.0 | 200 | 37.5 | 240 | 6.1 | 6.7 | 6 |
| 17 | ...... | ...... | ...... | ...... | 30.8 | 197 | 37.7 | 233 | 42.8 | 281 | 6.2 | 5.9 | 8 |
| | | | | | | | | | | | | | 317 |

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[1] Prepared by C. A. Lyford and Louis Margolin, 1906. The volumes in board feet are for actual saw cut, and therefore run much higher than if they were based on log scale. The volume in cubic feet includes bark.

TABLE 17.—*Volume of hemlock in cubic feet (including bark), Wisconsin (Marinette and Vilas Counties) and Michigan (Gogebic County).*

[Based on total height of tree.]

| Diameter breast-high. | Total height of tree—feet. | | | | | | | | Basis. |
|---|---|---|---|---|---|---|---|---|---|
| | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | |
| | Volume—cubic feet. | | | | | | | | |
| *Inches.* | | | | | | | | | *Trees.* |
| 5 | 1.0 | 1.2 | 1.7 | ........ | ........ | ........ | ........ | ........ | 18 |
| 6 | 2.0 | 2.6 | 3.3 | ........ | ........ | ........ | ........ | ........ | 16 |
| 7 | 3.1 | 4.1 | 5.2 | 5.9 | ........ | ........ | ........ | ........ | 28 |
| 8 | 4.1 | 5.5 | 7.3 | 8.4 | ........ | ........ | ........ | ........ | 53 |
| 9 | 5.4 | 7.4 | 9.3 | 10.9 | 12.3 | ........ | ........ | ........ | 72 |
| 10 | 7.0 | 9.5 | 11.9 | 14.1 | 15.7 | ........ | ........ | ........ | 56 |
| 11 | 8.6 | 11.8 | 14.6 | 17.2 | 19.6 | 22 | ........ | ........ | 53 |
| 12 | 10.6 | 14.4 | 18.0 | 21.0 | 24.0 | 26 | ........ | ........ | 46 |
| 13 | 12.5 | 17.0 | 21.0 | 24.0 | 28.0 | 31 | 33 | ........ | 35 |
| 14 | 14.8 | 20.0 | 24.0 | 28.0 | 33.0 | 37 | 39 | ........ | 18 |
| 15 | 17.0 | 23.0 | 28.0 | 33.0 | 38.0 | 42 | 45 | ........ | 31 |
| 16 | 19.3 | 26.0 | 32.0 | 38.0 | 44.0 | 48 | 51 | 54 | 25 |
| 17 | ........ | ........ | 36.0 | 43.0 | 50.0 | 54 | 59 | 62 | 30 |
| 18 | ........ | ........ | 41.0 | 48.0 | 56.0 | 61 | 67 | 71 | 14 |
| 19 | ........ | ........ | 45.0 | 54.0 | 62.0 | 69 | 75 | 79 | 16 |
| 20 | ........ | ........ | 50.0 | 60.0 | 69.0 | 77 | 83 | 87 | 20 |
| 21 | ........ | ........ | ........ | 66.0 | 76.0 | 85 | 91 | 98 | 11 |
| 22 | ........ | ........ | ........ | 72.0 | 83.0 | 93 | 100 | 109 | 13 |
| 23 | ........ | ........ | ........ | 79.0 | 91.0 | 102 | 109 | 119 | 4 |
| 24 | ........ | ........ | ........ | 85.0 | 99.0 | 111 | 119 | 129 | 6 |
| 25 | ........ | ........ | ........ | ........ | 107.0 | 120 | 131 | 143 | 9 |
| 26 | ........ | ........ | ........ | ........ | 116.0 | 130 | 144 | 156 | 4 |
| 27 | ........ | ........ | ........ | ........ | 123.0 | 139 | 155 | 169 | 8 |
| 28 | ........ | ........ | ........ | ........ | 131.0 | 147 | 167 | 182 | 6 |
| 29 | ........ | ........ | ........ | ........ | ........ | 157 | 179 | 195 | 3 |
| 30 | ........ | ........ | ........ | ........ | ........ | 169 | 191 | 208 | 1 |
| 31 | ........ | ........ | ........ | ........ | ........ | 180 | 204 | 222 | 2 |
| 32 | ........ | ........ | ........ | ........ | ........ | 192 | 218 | 237 | 1 |
| 33 | ........ | ........ | ........ | ........ | ........ | ........ | 231 | 252 | 3 |
| 34 | ........ | ........ | ........ | ........ | ........ | ........ | 246 | 267 | 1 |
| 35 | ........ | ........ | ........ | ........ | ........ | ........ | 260 | 283 | 1 |
| 36 | ........ | ........ | ........ | ........ | ........ | ........ | 275 | 299 | ........ |
| | | | | | | | | | 604 |

Based on taper curves. Volume includes stem with bark between a 2-foot stump and a 4-inch top. Bark forms 19 per cent of the total volume of the stem.

Table 18 shows the average amount of bark obtainable per 1,000 board feet from hemlock trees of different sizes in the Southern Appalachians.

TABLE 18.—*Cords of bark per 1,000 board feet (Doyle-Scribner) for hemlock trees of different sizes in the Southern Appalachians.*[1]

| Diameter breast-high. | Cords per 1,000 board feet. | Diameter breast-high. | Cords per 1,000 board feet. | Diameter breast-high. | Cords per 1,000 board feet. |
|---|---|---|---|---|---|
| *Inches.* | | *Inches.* | | *Inches.* | |
| 12 | 2.8 | 18 | 1.1 | 25 | 0.6 |
| 13 | 2.3 | 19 | 1.0 | 26 | .6 |
| 14 | 1.9 | 20 | .9 | 27 | .5 |
| 15 | 1.6 | 21 | .8 | 28 | .5 |
| 16 | 1.3 | 22 | .8 | 29 | .5 |
| 17 | 1.2 | 23 | .7 | 30 | .4 |
| ............ | ............ | 24 | .7 | ............ | ............ |

[1] From data secured under the direction of Walter Mulford, 1905-6.

TABLE 19.—*Volume of hemlock bark, in cords, for trees over and under 100 feet in height, Southern Appalachian region.*[1]

| Diameter breast-high. | Trees 100 feet and under. | Trees 100 feet and over. | Basis. | Diameter breast-high. | Trees 100 feet and under. | Trees 100 feet and over. | Basis. |
|---|---|---|---|---|---|---|---|
| | Volume of bark. | | | | Volume of bark. | | |
| *Inches.* | *Cord.* | *Cord.* | *Trees.* | *Inches.* | *Cord.* | *Cord.* | *Trees.* |
| 10 | 0.10 | ............ | 1 | 31 | 0.42 | 0.48 | 26 |
| 11 | .11 | ............ | 1 | 32 | .43 | .50 | 18 |
| 12 | .11 | ............ | 2 | 33 | .45 | .52 | 23 |
| 13 | .12 | ............ | 5 | 34 | .47 | .55 | 20 |
| 14 | .13 | ............ | 12 | 35 | .48 | .57 | 14 |
| 15 | .14 | 0.18 | 14 | | | | |
| | | | | 36 | .50 | .59 | 14 |
| 16 | .15 | .19 | 20 | 37 | .52 | .62 | 8 |
| 17 | .17 | .21 | 30 | 38 | .53 | .64 | 11 |
| 18 | .19 | .23 | 35 | 39 | .55 | .67 | 5 |
| 19 | .21 | .25 | 33 | 40 | .56 | .69 | 5 |
| 20 | .23 | .26 | 28 | | | | |
| | | | | 41 | .58 | .72 | 4 |
| 21 | .25 | .28 | 36 | 42 | .60 | .75 | 6 |
| 22 | .27 | .30 | 35 | 43 | ............ | .78 | 1 |
| 23 | .29 | .32 | 50 | 44 | ............ | .81 | ............ |
| 24 | .30 | .34 | 30 | 45 | ............ | .84 | 1 |
| 25 | .32 | .36 | 36 | | | | |
| | | | | 46 | ............ | .87 | 2 |
| 26 | .34 | .38 | 33 | 47 | ............ | .91 | 2 |
| 27 | .35 | .40 | 38 | 48 | ............ | .94 | 2 |
| 28 | .37 | .42 | 32 | | | | |
| 29 | .39 | .44 | 22 | | | | 682 |
| 30 | .40 | .46 | 27 | | | | |

[1] Prepared under the direction of Walter Mulford, 1905-6.

TABLE 20.—*Volume of hemlock bark in stacked cords—Vermont.*[1]

| Diameter breast-high. | Volume of bark. | Diameter breast-high. | Volume of bark. |
|---|---|---|---|
| *Inches.* | *Cord.* | *Inches.* | *Cord.* |
| 8 | 0.03 | 21 | 0.25 |
| 9 | .05 | 22 | .28 |
| 10 | .06 | 23 | .31 |
| 11 | .07 | 24 | .34 |
| 12 | .08 | 25 | .37 |
| 13 | .09 | 26 | .40 |
| 14 | .10 | 27 | .43 |
| 15 | .12 | 28 | .46 |
| 16 | .14 | 29 | .50 |
| 17 | .16 | | |
| 18 | .18 | | |
| 19 | .20 | | |
| 20 | .22 | | |

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[1] From "Hemlock in Vermont," by A. F. Hawes, State forester; Vt. Agr. Exp. Sta. Bulletin 161 (January, 1912), p. 8. The table was constructed by "subtracting the volumes of the trees inside the bark from their volumes outside the bark, and multiplying by 0.4, on the assumption that 40 per cent of an average stacked cord of bark is solid bark." The accuracy of this factor (taken from Schenck's "Forest Mensuration," 1905, p. 14) was borne out by investigations of a few piles of bark.

The following taper tables give diameters inside bark at different heights for average hemlock trees of various sizes in the Lake States and Southern Appalachians. The distances from the ground are in units of 8.15 feet above a 2-foot stump. These units represent the half of a 16.3-foot log. The practical use of these tables is to permit scaling trees of given size in terms of any desired log rule, but they also serve as a basis for comparing hemlock with other species in regard to form. The tables were prepared from existing measurements by W. B. Barrows.

TABLE 21.—*Diameters inside bark at different heights above the ground for trees of different sizes, based on measurements of 614 trees in Wisconsin (Marinette and Vilas Counties) and Michigan (Gogebic County).*

[The heights above ground represent 16.3-foot logs and half logs, plus a stump height of 2 feet.]

| Diameter breast-high outside bark. | 30-foot trees. | | 40-foot trees. | | | 50-foot trees. | | | | 60-foot trees. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Height above ground—feet. | | | | | | | | | | | | | | |
| | 10.15 | 18.3 | 10.15 | 18.3 | 26.45 | 10.15 | 18.3 | 26.45 | 34.6 | 10.15 | 18.3 | 26.45 | 34.6 | 42.75 | 50.9 |
| | Diameter inside bark—inches. | | | | | | | | | | | | | | |
| *Inches.* | | | | | | | | | | | | | | | |
| 4 | 3.0 | 1.4 | 3.1 | 2.4 | 1.6 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | .... |
| 5 | 3.9 | 2.0 | 3.9 | 3.1 | 2.1 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | .... |
| 6 | 4.7 | 2.5 | 4.8 | 3.9 | 2.6 | 5.3 | 4.5 | 3.6 | 2.4 | ...... | ...... | ...... | ...... | ...... | .... |
| 7 | 5.6 | 3.2 | 5.7 | 4.7 | 3.1 | 6.1 | 5.3 | 4.1 | 2.8 | 6.0 | 5.5 | 4.7 | 3.6 | 2.4 | 1.3 |
| 8 | 6.4 | 3.9 | 6.6 | 5.3 | 3.6 | 6.9 | 6.1 | 4.8 | 3.2 | 6.8 | 6.2 | 5.3 | 4.2 | 2.9 | 1.5 |
| 9 | 7.4 | 4.5 | 7.5 | 6.0 | 4.1 | 7.7 | 6.8 | 5.4 | 3.6 | 7.6 | 6.9 | 6.1 | 4.8 | 3.3 | 1.7 |
| 10 | 8.1 | 5.1 | 8.3 | 6.8 | 4.6 | 8.5 | 7.6 | 6.1 | 4.0 | 8.5 | 7.8 | 6.8 | 5.4 | 3.7 | 2.0 |
| 11 | ...... | ...... | 9.2 | 7.5 | 5.1 | 9.3 | 8.3 | 6.6 | 4.4 | 9.2 | 8.5 | 7.5 | 6.0 | 4.1 | 2.2 |
| 12 | ...... | ...... | 10.0 | 8.2 | 5.7 | 10.1 | 9.0 | 7.3 | 4.8 | 10.0 | 9.5 | 8.3 | 6.6 | 4.6 | 2.4 |
| 13 | ...... | ...... | 10.9 | 8.9 | 6.2 | 10.9 | 9.8 | 7.8 | 5.2 | 10.8 | 10.1 | 9.0 | 7.2 | 5.0 | 2.6 |
| 14 | ...... | ...... | 11.8 | 9.6 | 6.8 | 11.6 | 10.5 | 8.5 | 5.6 | 11.6 | 10.9 | 9.7 | 7.8 | 5.5 | 2.9 |
| 15 | ...... | ...... | 12.7 | 10.3 | 7.3 | 12.3 | 11.2 | 9.0 | 6.0 | 12.5 | 11.6 | 10.4 | 8.4 | 5.9 | 3.2 |
| 16 | ...... | ...... | ...... | ...... | ...... | 13.0 | 11.9 | 9.7 | 6.4 | 13.3 | 12.5 | 11.1 | 9.0 | 6.4 | 3.6 |
| 17 | ...... | ...... | ...... | ...... | ...... | 13.8 | 12.6 | 10.2 | 6.9 | 14.1 | 13.2 | 11.8 | 9.5 | 6.8 | 3.7 |
| 18 | ...... | ...... | ...... | ...... | ...... | 14.5 | 13.3 | 10.8 | 7.3 | 14.8 | 14.1 | 12.5 | 10.1 | 7.3 | 4.1 |
| 19 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 15.7 | 14.9 | 13.2 | 10.7 | 7.7 | 4.4 |
| 20 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 16.4 | 15.7 | 13.9 | 11.3 | 8.2 | 4.7 |
| 21 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 17.2 | 16.5 | 14.7 | 11.9 | 8.6 | 4.8 |
| 22 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 17.9 | 17.3 | 15.4 | 12.5 | 9.0 | 5.0 |

TABLE 21.—*Diameters inside bark at different heights above the ground for trees of different sizes, based on measurements of 614 trees in Wisconsin (Marinette and Vilas Counties) and Michigan (Gogebic County)*—Continued.

| Diameter breast-high outside bark. | 70-foot trees. | | | | | | | 80-foot trees. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Height above ground—feet. | | | | | | | | | | | | | | |
| | 10.15 | 18.3 | 26.45 | 34.6 | 42.75 | 50.9 | 59.05 | 10.15 | 18.3 | 26.45 | 34.6 | 42.75 | 50.9 | 59.05 | 67.2 |
| | Diameter inside bark—inches. | | | | | | | | | | | | | | |
| *Inches.* | | | | | | | | | | | | | | | |
| 9 | 7.7 | 7.1 | 6.4 | 5.5 | 4.3 | 3.0 | 1.5 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | .... |
| 10 | 8.5 | 7.9 | 7.1 | 6.1 | 4.9 | 3.5 | 1.9 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | .... |
| 11 | 9.3 | 8.6 | 7.9 | 6.8 | 5.5 | 3.9 | 2.2 | 9.3 | 8.7 | 8.1 | 7.4 | 6.4 | 5.1 | 3.6 | 2.1 |
| 12 | 10.1 | 9.4 | 8.5 | 7.4 | 6.1 | 4.3 | 2.5 | 10.2 | 9.4 | 8.8 | 8.1 | 7.1 | 5.6 | 4.0 | 2.3 |
| 13 | 10.9 | 10.2 | 9.3 | 8.2 | 6.7 | 4.8 | 2.7 | 11.0 | 10.2 | 9.5 | 8.7 | 7.6 | 6.2 | 4.4 | 2.5 |
| 14 | 11.7 | 10.9 | 10.1 | 8.8 | 7.2 | 5.3 | 3.0 | 11.8 | 11.0 | 10.3 | 9.4 | 8.3 | 6.7 | 4.8 | 2.6 |
| 15 | 12.5 | 11.7 | 10.8 | 9.5 | 7.8 | 5.7 | 3.3 | 12.5 | 11.7 | 11.1 | 10.1 | 8.8 | 7.3 | 5.2 | 3.0 |
| 16 | 13.2 | 12.4 | 11.6 | 10.2 | 8.4 | 6.2 | 3.6 | 13.3 | 12.4 | 11.7 | 10.8 | 9.5 | 7.8 | 5.6 | 3.3 |
| 17 | 14.0 | 13.1 | 12.3 | 10.9 | 8.9 | 6.6 | 3.9 | 13.9 | 13.2 | 12.5 | 11.5 | 10.1 | 8.3 | 6.1 | 3.6 |
| 18 | 14.7 | 13.8 | 13.0 | 11.6 | 9.6 | 7.1 | 4.1 | 14.6 | 13.9 | 13.2 | 12.2 | 10.7 | 8.9 | 6.5 | 3.8 |
| 19 | 15.4 | 11.5 | 13.6 | 12.2 | 10.1 | 7.5 | 4.3 | 15.4 | 14.7 | 14.0 | 12.9 | 11.4 | 9.5 | 7.0 | 4.1 |
| 20 | 16.2 | 15.1 | 14.4 | 12.9 | 10.7 | 7.9 | 4.6 | 16.1 | 15.3 | 14.7 | 13.6 | 12.1 | 10.0 | 7.4 | 4.4 |
| 21 | 16.9 | 15.9 | 15.1 | 13.6 | 11.3 | 8.4 | 4.8 | 16.9 | 16.0 | 15.3 | 14.3 | 12.7 | 10.6 | 7.8 | 4.7 |
| 22 | 17.6 | 16.4 | 15.8 | 14.3 | 11.9 | 8.8 | 5.1 | 17.6 | 16.7 | 16.0 | 15.0 | 13.3 | 11.1 | 8.2 | 4.9 |
| 23 | 18.3 | 17.3 | 16.4 | 14.9 | 12.5 | 9.3 | 5.3 | 18.3 | 17.4 | 16.7 | 15.7 | 14.0 | 11.7 | 8.7 | 5.2 |
| 24 | 19.0 | 17.8 | 17.1 | 15.5 | 13.1 | 9.7 | 5.6 | 19.0 | 18.0 | 17.3 | 16.4 | 14.7 | 12.3 | 9.0 | 5.4 |
| 25 | 19.7 | 18.5 | 17.7 | 16.1 | 13.6 | 10.1 | 5.8 | 19.8 | 18.8 | 18.1 | 17.1 | 15.4 | 12.9 | 9.5 | 5.6 |
| 26 | 20.4 | 19.2 | 18.3 | 16.8 | 14.2 | 10.5 | 6.0 | 20.5 | 19.4 | 18.7 | 17.7 | 16.0 | 13.4 | 9.9 | 5.9 |
| 27 | 21.1 | 19.8 | 18.9 | 17.4 | 14.8 | 10.9 | 6.2 | 21.2 | 20.1 | 19.5 | 18.5 | 16.6 | 14.1 | 10.3 | 6.1 |
| 28 | 21.9 | 20.4 | 19.4 | 18.0 | 15.3 | 11.4 | 6.4 | 21.9 | 20.7 | 20.0 | 19.1 | 17.3 | 14.6 | 10.7 | 6.3 |
| 29 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 22.7 | 21.4 | 20.7 | 19.8 | 18.0 | 15.2 | 11.1 | 6.6 |
| 30 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 23.3 | 22.0 | 21.3 | 20.5 | 18.7 | 15.8 | 11.5 | 6.8 |
| 31 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 24.1 | 22.7 | 22.0 | 21.1 | 19.4 | 16.5 | 12.0 | 7.1 |
| 32 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 24.7 | 23.3 | 22.6 | 21.8 | 20.1 | 17.0 | 12.4 | 7.3 |

| Diameter breast-high outside bark. | 90-foot trees. | | | | | | | | | 100-foot trees. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Height above ground—feet. | | | | | | | | | | | | | | | | | | |
| | 10.15 | 18.3 | 26.45 | 34.6 | 42.75 | 50.9 | 59.05 | 67.2 | 75.35 | 10.15 | 18.3 | 26.45 | 34.6 | 42.75 | 50.9 | 59.05 | 67.2 | 75.35 | 83.5 |
| | Diameter inside bark—inches. | | | | | | | | | | | | | | | | | | |
| *Inches.* | | | | | | | | | | | | | | | | | | | |
| 13 | 11.0 | 10.2 | 9.6 | 8.7 | 7.7 | 6.7 | 5.3 | 3.9 | 2.4 | ..... | .... | ..... | .... | ..... | .... | ..... | .... | ..... | .... |
| 14 | 11.7 | 10.9 | 10.3 | 9.5 | 8.5 | 7.3 | 5.8 | 4.3 | 2.6 | ..... | .... | ..... | .... | ..... | .... | ..... | .... | ..... | .... |
| 15 | 12.5 | 11.7 | 11.1 | 10.2 | 9.2 | 8.0 | 6.4 | 4.6 | 2.9 | ..... | .... | ..... | .... | ..... | .... | ..... | .... | ..... | .... |
| 16 | 13.2 | 12.4 | 11.7 | 10.9 | 9.9 | 8.6 | 6.9 | 5.0 | 3.1 | 12.6 | 11.7 | 11.3 | 11.0 | 10.4 | 9.3 | 7.9 | 6.4 | 4.9 | 3.3 |
| 17 | 14.0 | 13.1 | 12.5 | 11.7 | 10.6 | 9.3 | 7.5 | 5.4 | 3.3 | 13.4 | 12.6 | 12.2 | 11.8 | 11.1 | 10.0 | 8.5 | 6.9 | 5.3 | 3.5 |
| 18 | 14.7 | 13.9 | 13.2 | 12.4 | 11.3 | 9.9 | 8.0 | 5.8 | 3.6 | 14.3 | 13.4 | 12.9 | 12.5 | 11.7 | 10.6 | 9.1 | 7.5 | 5.7 | 3.7 |
| 19 | 15.4 | 14.6 | 13.9 | 13.1 | 12.0 | 10.6 | 8.5 | 6.2 | 3.9 | 15.1 | 14.2 | 13.7 | 13.3 | 12.4 | 11.2 | 9.7 | 8.0 | 6.0 | 4.0 |
| 20 | 16.1 | 15.3 | 14.7 | 13.9 | 12.8 | 11.2 | 9.1 | 6.6 | 4.1 | 15.8 | 15.0 | 14.6 | 14.0 | 13.1 | 11.8 | 10.3 | 8.5 | 6.4 | 4.2 |
| 21 | 16.9 | 16.0 | 15.4 | 14.6 | 13.4 | 11.8 | 9.7 | 7.0 | 4.3 | 16.7 | 15.9 | 15.3 | 14.7 | 13.7 | 12.4 | 10.9 | 9.0 | 6.7 | 4.4 |
| 22 | 17.6 | 16.7 | 16.1 | 15.3 | 14.1 | 12.4 | 10.3 | 7.4 | 4.6 | 17.5 | 16.7 | 16.1 | 15.4 | 14.4 | 13.0 | 11.5 | 9.5 | 7.1 | 4.6 |
| 23 | 18.3 | 17.5 | 16.8 | 16.0 | 14.8 | 13.1 | 10.8 | 7.9 | 4.9 | 18.3 | 17.5 | 16.9 | 16.1 | 15.0 | 13.7 | 12.1 | 10.0 | 7.5 | 4.8 |
| 24 | 19.0 | 18.1 | 17.5 | 16.7 | 15.5 | 13.7 | 11.3 | 8.3 | 5.1 | 19.1 | 18.3 | 17.6 | 16.8 | 15.7 | 14.4 | 12.7 | 10.5 | 7.9 | 5.0 |
| 25 | 19.9 | 18.9 | 18.2 | 17.4 | 16.2 | 14.3 | 11.9 | 8.7 | 5.4 | 19.9 | 19.1 | 13.5 | 17.5 | 16.4 | 15.0 | 13.3 | 11.1 | 8.4 | 5.3 |
| 26 | 20.6 | 19.6 | 18.9 | 18.1 | 16.8 | 15.0 | 12.4 | 9.2 | 5.8 | 20.7 | 19.9 | 19.2 | 18.3 | 17.0 | 15.6 | 13.9 | 11.6 | 8.7 | 5.6 |
| 27 | 21.4 | 20.4 | 19.7 | 18.8 | 17.5 | 15.6 | 13.0 | 9.7 | 6.0 | 21.5 | 20.7 | 20.0 | 19.0 | 17.7 | 16.3 | 14.5 | 12.0 | 9.1 | 5.8 |
| 28 | 22.1 | 21.2 | 20.3 | 19.4 | 18.2 | 16.3 | 13.5 | 10.0 | 6.2 | 22.3 | 21.4 | 20.6 | 19.7 | 18.4 | 16.9 | 15.1 | 12.5 | 9.4 | 6.1 |
| 29 | 22.9 | 21.9 | 21.1 | 20.2 | 18.9 | 16.9 | 14.1 | 10.4 | 6.5 | 23.2 | 22.3 | 21.5 | 20.5 | 19.2 | 17.5 | 15.6 | 13.0 | 9.8 | 6.2 |
| 30 | 23.6 | 22.6 | 21.8 | 20.8 | 19.5 | 17.6 | 14.5 | 10.8 | 6.8 | 23.9 | 23.0 | 22.2 | 21.2 | 19.8 | 18.2 | 16.2 | 13.5 | 10.1 | 6.4 |
| 31 | 24.3 | 23.3 | 22.5 | 21.5 | 20.1 | 18.2 | 15.2 | 11.2 | 7.1 | 24.7 | 23.8 | 22.9 | 21.9 | 20.5 | 18.9 | 16.9 | 14.1 | 10.5 | 6.6 |
| 32 | 25.0 | 24.0 | 23.1 | 22.1 | 20.8 | 18.8 | 15.6 | 11.6 | 7.4 | 25.4 | 24.5 | 23.7 | 22.6 | 21.1 | 19.5 | 17.5 | 14.6 | 10.8 | 6.8 |
| 33 | 25.8 | 24.8 | 23.9 | 22.8 | 21.4 | 19.5 | 16.2 | 12.0 | 7.6 | 26.3 | 25.3 | 24.4 | 23.3 | 21.8 | 20.1 | 18.0 | 15.1 | 11.2 | 7.0 |
| 34 | 26.5 | 25.5 | 24.6 | 23.4 | 22.0 | 20.2 | 16.8 | 12.4 | 7.9 | 27.1 | 26.1 | 25.1 | 24.0 | 22.5 | 20.8 | 18.6 | 15.6 | 11.5 | 7.1 |
| 35 | 27.3 | 26.2 | 25.3 | 24.1 | 22.7 | 20.8 | 17.3 | 12.9 | 8.2 | 27.9 | 26.8 | 25.9 | 24.7 | 23.2 | 21.5 | 19.2 | 16.1 | 12.0 | 7.3 |
| 36 | 28.1 | 26.9 | 25.9 | 24.7 | 23.3 | 21.4 | 17.7 | 13.2 | 8.5 | 28.7 | 27.6 | 26.6 | 25.4 | 23.9 | 22.2 | 19.9 | 16.6 | 12.3 | 7.5 |
| 37 | 28.9 | 27.7 | 26.7 | 25.4 | 23.9 | 22.0 | 18.3 | 13.7 | 8.8 | 29.5 | 28.4 | 27.3 | 26.2 | 24.7 | 22.8 | 20.4 | 17.1 | 12.7 | 7.7 |
| 38 | 29.6 | 28.3 | 27.3 | 26.1 | 24.5 | 22.5 | 18.8 | 14.2 | 9.1 | 30.3 | 29.1 | 28.0 | 26.8 | 25.3 | 23.4 | 21.0 | 17.6 | 13.0 | 7.9 |

TABLE 22.—*Diameters inside bark at different heights above the ground for trees of different sizes, based on measurements of 1,548 trees in the Southern Appalachian region.*

[The heights above ground represent 16.3-foot logs and half logs plus a stump height of 2 feet.]

| Diameter breast-high outside bark. | 20-foot trees. | 30-foot trees. | 40-foot trees. | | |
|---|---|---|---|---|---|
| | Height above ground—feet. | | | | |
| | 10.15 | 10.15 | 10.15 | 18.3 | 26.45 |
| | Diameter inside bark—inches. | | | | |
| *Inches.* | | | | | |
| 2 | 1.1 | 1.3 | ...... | ...... | ...... |
| 3 | 1.9 | 2.1 | ...... | ...... | ...... |
| 4 | 2.6 | 3.0 | 3.2 | 2.6 | 1.6 |
| 5 | 3.3 | 3.8 | 4.1 | 3.1 | 2.0 |
| 6 | ...... | 4.7 | 4.9 | 3.9 | 2.5 |
| 7 | ...... | 5.5 | 5.8 | 4.6 | 3.0 |
| 8 | ...... | 6.3 | 6.6 | 5.3 | 3.6 |
| 9 | ...... | 7.3 | 7.5 | 6.1 | 4.0 |
| 10 | ...... | 8.1 | 8.3 | 6.8 | 4.5 |
| 11 | ...... | ...... | 9.2 | 7.6 | 5.0 |
| 12 | ...... | ...... | 10.1 | 8.3 | 5.5 |
| 13 | ...... | ...... | 10.9 | 9.1 | 6.0 |
| 14 | ...... | ...... | 11.8 | 9.9 | 6.5 |

| Diameter breast-high outside bark. | 50-foot trees. | | | | | 60-foot trees. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Height above ground—feet. | | | | | | | | | | |
| | 10.15 | 18.3 | 26.45 | 34.6 | 42.75 | 10.15 | 18.3 | 26.45 | 34.6 | 42.75 | 50.9 |
| | Diameter inside bark—inches. | | | | | | | | | | |
| *Inches.* | | | | | | | | | | | |
| 4 | 3.3 | 2.6 | 2.0 | 1.3 | 0.6 | ...... | ...... | ...... | ...... | ...... | ...... |
| 5 | 4.1 | 3.5 | 2.7 | 1.8 | .8 | ...... | ...... | ...... | ...... | ...... | ...... |
| 6 | 5.0 | 4.2 | 3.3 | 2.2 | 1.0 | 5.1 | 4.4 | 3.8 | 3.0 | 2.1 | 1.0 |
| 7 | 5.8 | 5.0 | 4.0 | 2.7 | 1.2 | 5.9 | 5.3 | 4.5 | 3.6 | 2.5 | 1.2 |
| 8 | 6.6 | 5.8 | 4.6 | 3.1 | 1.4 | 6.8 | 6.1 | 5.2 | 4.2 | 3.0 | 1.5 |
| 9 | 7.4 | 6.6 | 5.3 | 3.6 | 1.7 | 7.6 | 6.9 | 6.0 | 4.9 | 3.4 | 1.7 |
| 10 | 8.4 | 7.4 | 5.9 | 4.0 | 1.9 | 8.5 | 7.7 | 6.7 | 5.5 | 3.9 | 1.9 |
| 11 | 9.2 | 8.2 | 6.6 | 4.5 | 2.1 | 9.3 | 8.5 | 7.5 | 6.2 | 4.4 | 2.2 |
| 12 | 10.1 | 9.0 | 7.2 | 4.9 | 2.3 | 10.1 | 9.4 | 8.3 | 6.9 | 4.9 | 2.4 |
| 13 | 10.9 | 9.8 | 8.0 | 5.4 | 2.6 | 11.0 | 10.2 | 9.0 | 7.5 | 5.4 | 2.8 |
| 14 | 11.8 | 10.6 | 8.6 | 6.0 | 2.9 | 11.9 | 11.1 | 9.8 | 8.2 | 6.0 | 3.0 |
| 15 | 12.6 | 11.4 | 9.3 | 6.5 | 3.2 | 12.7 | 11.9 | 10.6 | 8.9 | 6.5 | 3.3 |
| 16 | 13.6 | 12.3 | 10.0 | 7.0 | 3.5 | 13.6 | 12.7 | 11.4 | 9.6 | 7.0 | 3.6 |
| 17 | 14.4 | 13.1 | 10.7 | 7.5 | 3.7 | 14.4 | 13.5 | 12.1 | 10.2 | 7.5 | 3.9 |
| 18 | 15.3 | 13.9 | 11.4 | 8.0 | 4.0 | 15.3 | 14.4 | 12.9 | 10.9 | 8.0 | 4.2 |
| 19 | 16.1 | 14.7 | 12.1 | 8.6 | 4.3 | 16.1 | 15.1 | 13.7 | 11.5 | 8.5 | 4.5 |
| 20 | 17.0 | 15.5 | 12.8 | 9.1 | 4.7 | 17.0 | 16.0 | 14.4 | 12.2 | 9.0 | 4.8 |
| 21 | ...... | ...... | ...... | ...... | ...... | 17.8 | 16.7 | 15.2 | 12.9 | 9.5 | 5.1 |
| 22 | ...... | ...... | ...... | ...... | ...... | 18.7 | 17.6 | 15.9 | 13.5 | 10.0 | 5.4 |
| 23 | ...... | ...... | ...... | ...... | ...... | 19.6 | 18.3 | 16.7 | 14.2 | 10.5 | 5.7 |
| 24 | ...... | ...... | ...... | ...... | ...... | 20.4 | 19.1 | 17.4 | 14.8 | 11.0 | 6.1 |
| 25 | ...... | ...... | ...... | ...... | ...... | 21.3 | 19.9 | 18.1 | 15.4 | 11.4 | 6.3 |
| 26 | ...... | ...... | ...... | ...... | ...... | 22.1 | 20.6 | 18.8 | 16.0 | 11.9 | 6.7 |
| 27 | ...... | ...... | ...... | ...... | ...... | 23.0 | 21.4 | 19.5 | 16.6 | 12.4 | 7.0 |

TABLE 22.—*Diameters inside bark at different heights above the ground for trees of different sizes, based on measurements of 1,548 trees in the Southern Appalachian region*—Con.

| Diameter breast-high outside bark. | 70-foot trees. | | | | | | | 80-foot trees. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Height above ground—feet. | | | | | | | | | | | | | | | |
| | 10.15 | 18.3 | 26.45 | 34.6 | 42.75 | 50.9 | 59.05 | 10.15 | 18.3 | 26.45 | 34.6 | 42.75 | 50.9 | 59.05 | 67.2 | 73.35 |
| | Diameter inside bark—inches. | | | | | | | | | | | | | | | |
| *Inches.* | | | | | | | | | | | | | | | | |
| 8 | 6.8 | 6.2 | 5.7 | 5.0 | 4.0 | 2.9 | 1.7 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 9 | 7.9 | 7.0 | 6.5 | 5.8 | 4.7 | 3.4 | 2.0 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 10 | 8.5 | 7.9 | 7.3 | 6.5 | 5.3 | 3.8 | 2.2 | 8.7 | 8.1 | 7.5 | 6.9 | 6.1 | 5.0 | 3.7 | 2.2 | 1.1 |
| 11 | 9.4 | 8.8 | 8.1 | 7.2 | 5.9 | 4.2 | 2.4 | 9.5 | 9.0 | 8.3 | 7.7 | 6.8 | 5.5 | 4.1 | 2.4 | 1.2 |
| 12 | 10.2 | 9.5 | 8.9 | 7.9 | 6.4 | 4.7 | 2.7 | 10.3 | 9.8 | 9.2 | 8.5 | 7.5 | 6.1 | 4.5 | 2.6 | 1.3 |
| 13 | 11.1 | 10.4 | 9.7 | 8.7 | 7.1 | 5.1 | 2.9 | 11.1 | 10.6 | 9.9 | 9.2 | 8.2 | 6.7 | 4.9 | 2.9 | 1.4 |
| 14 | 11.9 | 11.2 | 10.5 | 9.5 | 7.8 | 5.6 | 3.2 | 12.0 | 11.4 | 10.7 | 9.9 | 8.8 | 7.3 | 5.4 | 3.1 | 1.5 |
| 15 | 12.7 | 12.0 | 11.4 | 10.2 | 8.4 | 6.0 | 3.5 | 12.9 | 12.2 | 11.5 | 10.6 | 9.5 | 7.8 | 5.8 | 3.4 | 1.7 |
| 16 | 13.6 | 12.8 | 12.1 | 10.9 | 9.0 | 6.5 | 3.7 | 13.7 | 13.0 | 12.3 | 11.4 | 10.1 | 8.4 | 6.2 | 3.7 | 1.8 |
| 17 | 14.4 | 13.7 | 12.9 | 11.7 | 9.6 | 7.0 | 4.1 | 14.5 | 13.7 | 13.0 | 12.1 | 10.8 | 9.0 | 6.6 | 3.9 | 1.9 |
| 18 | 15.3 | 14.5 | 13.7 | 12.3 | 10.2 | 7.6 | 4.4 | 15.3 | 14.5 | 13.7 | 12.7 | 11.3 | 9.5 | 7.0 | 4.1 | 2.1 |
| 19 | 16.1 | 15.2 | 14.4 | 13.0 | 10.8 | 8.1 | 4.7 | 16.2 | 15.3 | 14.4 | 13.4 | 12.0 | 10.1 | 7.5 | 4.4 | 2.2 |
| 20 | 17.0 | 16.0 | 15.2 | 13.7 | 11.4 | 8.6 | 5.0 | 17.0 | 16.0 | 15.2 | 14.1 | 12.6 | 10.7 | 7.9 | 4.6 | 2.3 |
| 21 | 17.9 | 16.8 | 15.9 | 14.4 | 12.0 | 9.1 | 5.3 | 17.9 | 16.9 | 15.9 | 14.8 | 13.3 | 11.2 | 8.4 | 4.9 | 2.4 |
| 22 | 18.7 | 17.6 | 16.6 | 15.0 | 12.5 | 9.6 | 5.6 | 18.7 | 17.5 | 16.5 | 15.5 | 13.9 | 11.8 | 8.9 | 5.2 | 2.5 |
| 23 | 19.6 | 18.4 | 17.3 | 15.7 | 13.1 | 10.0 | 5.9 | 19.6 | 18.4 | 17.3 | 16.1 | 14.5 | 12.3 | 9.2 | 5.5 | 2.7 |
| 24 | 20.4 | 19.1 | 18.1 | 16.3 | 13.6 | 10.5 | 6.2 | 20.4 | 19.1 | 18.0 | 16.8 | 15.1 | 12.8 | 9.7 | 5.8 | 2.8 |
| 25 | 21.3 | 19.9 | 18.7 | 17.0 | 14.2 | 10.9 | 6.5 | 21.3 | 19.9 | 18.8 | 17.4 | 15.7 | 13.4 | 10.1 | 6.0 | 3.0 |
| 26 | 22.1 | 20.6 | 19.4 | 17.5 | 14.7 | 11.3 | 6.8 | 22.1 | 20.7 | 19.5 | 18.1 | 16.2 | 13.9 | 10.6 | 6.3 | 3.1 |
| 27 | 22.9 | 21.4 | 20.1 | 18.2 | 15.3 | 11.7 | 7.1 | 23.0 | 21.5 | 20.3 | 18.8 | 16.9 | 14.4 | 11.0 | 6.6 | 3.3 |
| 28 | 23.7 | 22.1 | 20.9 | 18.8 | 15.8 | 12.2 | 7.3 | 23.8 | 22.2 | 20.9 | 19.4 | 17.4 | 14.8 | 11.3 | 6.9 | 3.4 |
| 29 | 24.6 | 22.9 | 21.6 | 19.5 | 16.4 | 12.6 | 7.6 | 24.6 | 23.0 | 21.7 | 20.1 | 18.0 | 15.3 | 11.8 | 7.2 | 3.6 |
| 30 | 25.4 | 23.7 | 22.3 | 20.1 | 16.9 | 12.9 | 7.9 | 25.5 | 23.8 | 22.4 | 20.8 | 18.7 | 15.9 | 12.2 | 7.5 | 3.8 |
| 31 | 26.2 | 24.5 | 23.0 | 20.8 | 17.5 | 13.3 | 8.2 | 26.3 | 24.6 | 23.1 | 21.4 | 19.2 | 16.3 | 12.5 | 7.7 | 4.0 |
| 32 | 27.0 | 25.2 | 23.7 | 21.4 | 18.0 | 13.7 | 8.5 | 27.1 | 25.3 | 23.7 | 22.0 | 19.7 | 16.7 | 12.8 | 8.0 | 4.1 |
| 33 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 28.0 | 26.1 | 24.4 | 22.6 | 20.3 | 17.1 | 13.1 | 8.2 | 4.2 |
| 34 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 28.8 | 26.8 | 25.2 | 23.4 | 20.8 | 17.5 | 13.4 | 8.4 | 4.4 |
| 35 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | 29.7 | 27.6 | 25.9 | 24.0 | 21.4 | 18.0 | 13.9 | 8.7 | 4.5 |

| Diameter breast-high outside bark. | 90-foot trees. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Height above ground—feet. | | | | | | | | | | |
| | 10.15 | 18.3 | 26.45 | 34.6 | 42.75 | 50.9 | 59.05 | 67.2 | 75.35 | 83.5 | 91.65 |
| | Diameter inside bark—inches. | | | | | | | | | | |
| *Inches.* | | | | | | | | | | | |
| 10 | 8.7 | 8.3 | 7.8 | 7.3 | 6.8 | 6.0 | 4.8 | 3.4 | 2.1 | 0.9 | ...... |
| 11 | 9.5 | 9.1 | 8.6 | 8.0 | 7.4 | 6.6 | 5.4 | 3.9 | 2.4 | 1.0 | ...... |
| 12 | 10.3 | 9.9 | 9.4 | 8.8 | 8.1 | 7.2 | 5.9 | 4.3 | 2.6 | 1.2 | ...... |
| 13 | 11.2 | 10.7 | 10.2 | 9.5 | 8.8 | 7.9 | 6.5 | 4.7 | 2.9 | 1.2 | ...... |
| 14 | 12.0 | 11.5 | 10.9 | 10.2 | 9.4 | 8.5 | 7.0 | 5.0 | 3.1 | 1 3. | ...... |
| 15 | 12.9 | 12.3 | 11.6 | 10.9 | 10.1 | 9.1 | 7.5 | 5.4 | 3.3 | 1.4 | ...... |
| 16 | 13.7 | 13.1 | 12.4 | 11.6 | 10.7 | 9.7 | 8.0 | 5.8 | 3.6 | 1.5 | ...... |
| 17 | 14.5 | 13.9 | 13.1 | 12.3 | 11.4 | 10.2 | 8.4 | 6.2 | 3.8 | 1.6 | ...... |
| 18 | 15.4 | 14.6 | 13.8 | 13.0 | 12.1 | 10.8 | 8.9 | 6.6 | 4.1 | 1.7 | ...... |
| 19 | 16.2 | 15.3 | 14.5 | 13.7 | 12.7 | 11.4 | 9.4 | 6.9 | 4.3 | 1.9 | ...... |
| 20 | 17.1 | 16.1 | 15.2 | 14.4 | 13.4 | 12.0 | 9.9 | 7.3 | 4.6 | 2.0 | ...... |
| 21 | 17.9 | 16.8 | 16.0 | 15.2 | 14.1 | 12.6 | 10.4 | 7.7 | 4.9 | 2.1 | ...... |
| 22 | 18.8 | 17.6 | 16.7 | 15.8 | 14.7 | 13.1 | 10.9 | 8.1 | 5.1 | 2.2 | ...... |
| 23 | 19.6 | 18.4 | 17.4 | 16.5 | 15.3 | 13.7 | 11.4 | 8.5 | 5.4 | 2.3 | ...... |
| 24 | 20.5 | 19.2 | 18.2 | 17.2 | 16.0 | 14.2 | 11.9 | 8.9 | 5.6 | 2.4 | ...... |
| 25 | 21.3 | 20.0 | 18.9 | 17.9 | 16.6 | 14.8 | 12.4 | 9.4 | 5.9 | 2.5 | ...... |

TABLE 22.—*Diameters inside bark at different heights above the ground for trees of different sizes, based on measurements of 1,548 trees in the Southern Appalachian region*—Con.

| Diameter breast-high outside bark. | 90-foot trees. | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Height above ground—feet. | | | | | | | | | | |
| | 10.15 | 18.3 | 26.45 | 34.6 | 42.75 | 50.9 | 59.05 | 67.2 | 75.35 | 83.5 | 91.65 |
| | Diameter inside bark—inches. | | | | | | | | | | |
| *Inches.* | | | | | | | | | | | |
| 26 | 22.2 | 20.7 | 19.7 | 18.6 | 17.2 | 15.3 | 12.9 | 9.8 | 6.1 | 2.6 | ...... |
| 27 | 23.0 | 21.5 | 20.4 | 19.3 | 17.9 | 16.0 | 13.4 | 10.2 | 6.5 | 2.8 | ...... |
| 28 | 23.8 | 22.3 | 21.1 | 19.9 | 18.4 | 16.5 | 13.9 | 10.6 | 6.7 | 2.9 | ...... |
| 29 | 24.7 | 23.1 | 21.9 | 20.6 | 19.1 | 17.1 | 14.4 | 11.0 | 7.1 | 3.1 | ...... |
| 30 | 25.5 | 23.8 | 22.6 | 21.3 | 19.7 | 17.6 | 14.9 | 11.4 | 7.3 | 3.2 | ...... |
| 31 | 26.3 | 24.6 | 23.3 | 22.0 | 20.3 | 18.2 | 15.4 | 11.8 | 7.6 | 3.4 | ...... |
| 32 | 27.2 | 25.4 | 24.0 | 22.6 | 20.9 | 18.6 | 15.8 | 12.2 | 7.8 | 3.5 | ...... |
| 33 | 28.0 | 26.2 | 24.8 | 23.3 | 21.5 | 19.2 | 16.4 | 12.6 | 8.1 | 3.6 | ...... |
| 34 | 28.8 | 27.0 | 25.5 | 24.0 | 22.1 | 19.7 | 16.8 | 13.0 | 8.4 | 3.7 | ...... |
| 35 | 29.6 | 27.7 | 26.2 | 24.6 | 22.7 | 20.2 | 17.3 | 13.4 | 8.6 | 3.8 | ...... |
| 36 | 30.5 | 28.6 | 26.9 | 25.4 | 23.3 | 20.7 | 17.8 | 13.7 | 8.8 | 3.9 | ...... |
| 37 | 31.3 | 29.3 | 27.7 | 26.1 | 23.9 | 21.2 | 18.3 | 14.2 | 9.2 | 4.0 | ...... |
| 38 | 32.2 | 30.1 | 28.4 | 26.8 | 24.6 | 21.7 | 18.7 | 14.6 | 9.4 | 4.1 | ...... |
| 39 | 33.0 | 30.8 | 29.1 | 27.4 | 25.2 | 22.2 | 19.2 | 15.0 | 9.7 | 4.2 | ...... |
| 40 | 33.8 | 31.6 | 29.8 | 28.1 | 25.7 | 22.7 | 19.6 | 15.3 | 9.9 | 4.3 | ...... |
| 41 | 34.6 | 32.4 | 30.6 | 28.7 | 26.4 | 23.3 | 20.1 | 15.7 | 10.3 | 4.6 | ...... |
| 42 | 35.4 | 33.2 | 31.3 | 29.3 | 26.9 | 23.8 | 20.5 | 16.2 | 10.8 | 4.8 | ...... |
| 43 | 36.2 | 34.0 | 32.1 | 30.0 | 27.6 | 24.4 | 20.9 | 16.6 | 11.1 | 5.0 | ...... |
| | 100-foot trees. | | | | | | | | | | |
| 12 | 10.3 | 9.9 | 9.4 | 8.9 | 8.3 | 7.6 | 6.7 | 5.4 | 4.0 | 2.6 | 1.3 |
| 13 | 11.2 | 10.7 | 10.1 | 9.6 | 9.0 | 8.3 | 7.2 | 5.9 | 4.4 | 2.9 | 1.5 |
| 14 | 12.0 | 11.5 | 10.9 | 10.3 | 9.7 | 8.9 | 7.7 | 6.3 | 4.7 | 3.1 | 1.6 |
| 15 | 12.9 | 12.3 | 11.6 | 11.0 | 10.4 | 9.7 | 8.3 | 6.8 | 5.2 | 3.4 | 1.8 |
| 16 | 13.8 | 13.0 | 12.4 | 11.8 | 11.1 | 10.1 | 8.9 | 7.3 | 5.6 | 3.8 | 2.0 |
| 17 | 14.6 | 13.8 | 13.1 | 12.4 | 11.8 | 10.8 | 9.5 | 7.9 | 6.0 | 4.0 | 2.1 |
| 18 | 15.5 | 14.6 | 13.8 | 13.1 | 12.3 | 11.4 | 10.1 | 8.4 | 6.4 | 4.3 | 2.2 |
| 19 | 16.2 | 15.3 | 14.5 | 13.8 | 13.0 | 12.0 | 10.7 | 8.9 | 6.8 | 4.6 | 2.3 |
| 20 | 17.1 | 16.1 | 15.3 | 14.5 | 13.6 | 12.6 | 11.3 | 9.3 | 7.2 | 4.8 | 2.4 |
| 21 | 18.0 | 16.9 | 16.0 | 15.2 | 14.4 | 13.3 | 11.8 | 9.9 | 7.6 | 5.1 | 2.5 |
| 22 | 18.8 | 17.7 | 16.8 | 16.0 | 15.0 | 13.9 | 12.3 | 10.3 | 8.0 | 5.3 | 2.6 |
| 23 | 19.7 | 18.5 | 17.5 | 16.6 | 15.7 | 14.6 | 12.9 | 10.8 | 8.3 | 5.6 | 2.8 |
| 24 | 20.5 | 19.2 | 18.3 | 17.4 | 16.4 | 15.1 | 13.5 | 11.3 | 8.7 | 5.7 | 2.9 |
| 25 | 21.4 | 20.0 | 18.9 | 18.1 | 17.1 | 15.8 | 14.0 | 11.8 | 9.0 | 6.0 | 3.0 |
| 26 | 22.2 | 20.8 | 19.7 | 18.7 | 17.7 | 16.3 | 14.6 | 12.3 | 9.4 | 6.2 | 3.1 |
| 27 | 23.1 | 21.6 | 20.5 | 19.6 | 18.5 | 17.0 | 15.2 | 12.8 | 9.8 | 6.5 | 3.2 |
| 28 | 23.9 | 22.3 | 21.3 | 20.2 | 19.1 | 17.6 | 15.8 | 13.3 | 10.1 | 6.7 | 3.3 |
| 29 | 24.7 | 23.2 | 22.1 | 21.1 | 19.9 | 18.3 | 16.4 | 13.8 | 10.5 | 6.9 | 3.5 |
| 30 | 25.5 | 24.0 | 22.9 | 21.8 | 20.5 | 18.8 | 16.9 | 14.3 | 10.8 | 7.1 | 3.6 |
| 31 | 26.4 | 24.7 | 23.6 | 22.6 | 21.2 | 19.4 | 17.5 | 14.8 | 11.2 | 7.4 | 3.7 |
| 32 | 27.2 | 25.5 | 24.4 | 23.3 | 21.9 | 20.1 | 18.1 | 15.2 | 11.5 | 7.6 | 3.8 |
| 33 | 28.1 | 26.3 | 25.2 | 24.1 | 22.6 | 20.7 | 18.7 | 15.8 | 12.0 | 7.9 | 4.0 |
| 34 | 28.8 | 27.0 | 25.9 | 24.8 | 23.2 | 21.3 | 19.2 | 16.3 | 12.3 | 8.0 | 4.1 |
| 35 | 29.7 | 27.8 | 26.7 | 25.5 | 23.9 | 22.0 | 19.8 | 16.8 | 12.7 | 8.3 | 4.3 |
| 36 | 30.5 | 28.6 | 27.4 | 26.2 | 24.6 | 22.6 | 20.3 | 17.2 | 13.1 | 8.6 | 4.4 |
| 37 | 31.4 | 29.4 | 28.2 | 26.9 | 25.3 | 23.2 | 20.9 | 17.7 | 13.4 | 8.8 | 4.5 |
| 38 | 32.2 | 30.1 | 28.9 | 27.6 | 25.9 | 23.8 | 21.4 | 18.1 | 13.7 | 9.1 | 4.6 |
| 39 | 33.1 | 30.9 | 29.6 | 28.3 | 26.6 | 24.5 | 22.0 | 18.6 | 14.1 | 9.3 | 4.9 |
| 40 | 33.8 | 31.7 | 30.3 | 29.0 | 27.3 | 25.1 | 22.6 | 19.1 | 14.4 | 9.5 | 5.0 |
| 41 | 34.7 | 32.4 | 31.1 | 29.8 | 28.1 | 25.8 | 23.1 | 19.6 | 14.8 | 9.7 | 5.1 |
| 42 | 35.5 | 33.3 | 31.8 | 30.5 | 28.8 | 26.4 | 23.7 | 20.1 | 15.1 | 9.9 | 5.2 |
| 43 | 36.3 | 34.0 | 32.5 | 31.2 | 29.5 | 27.1 | 24.3 | 20.6 | 15.5 | 10.3 | 5.4 |
| 44 | 37.1 | 34.8 | 33.2 | 31.9 | 30.2 | 27.7 | 24.9 | 21.1 | 15.9 | 10.5 | 5.5 |
| 45 | 37.9 | 35.5 | 34.0 | 32.6 | 30.9 | 28.4 | 25.5 | 21.5 | 16.3 | 10.9 | 5.7 |

TABLE 22.—*Diameters inside bark at different heights above the ground for trees of different sizes, based on measurements of 1,548 trees in the Southern Appalachian region*—Con.

| Diameter breast-high outside bark. | 110-foot trees. | | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | Height above ground—feet. | | | | | | | | | | | | |
| | 10.15 | 18.3 | 26.45 | 34.6 | 42.75 | 50.9 | 59.05 | 67.2 | 75.35 | 83.5 | 91.65 | 99.8 | 107.95 |
| | Diameter inside bark—inches. | | | | | | | | | | | | |
| *Inches.* | | | | | | | | | | | | | |
| 15 | 13.0 | 12.4 | 11.7 | 11.2 | 10.8 | 10.1 | 9.3 | 8.1 | 6.6 | 4.8 | 3.1 | 1.7 | ...... |
| 16 | 13.8 | 13.0 | 12.4 | 11.9 | 11.4 | 10.7 | 9.9 | 8.6 | 7.0 | 5.2 | 3.3 | 1.7 | ...... |
| 17 | 14.7 | 13.8 | 13.2 | 12.7 | 12.1 | 11.3 | 10.5 | 9.2 | 7.5 | 5.5 | 3.5 | 1.9 | ...... |
| 18 | 15.5 | 14.6 | 13.9 | 13.3 | 12.7 | 12.0 | 11.0 | 9.7 | 8.0 | 5.9 | 3.7 | 1.9 | ...... |
| 19 | 16.3 | 15.3 | 14.6 | 14.0 | 13.4 | 12.7 | 11.6 | 10.3 | 8.5 | 6.3 | 3.9 | 2.0 | ...... |
| 20 | 17.1 | 16.1 | 15.4 | 14.7 | 14.0 | 13.3 | 12.2 | 10.8 | 9.0 | 6.7 | 4.1 | 2.1 | ...... |
| 21 | 18.0 | 16.9 | 16.1 | 15.5 | 14.7 | 13.9 | 12.8 | 11.3 | 9.5 | 7.1 | 4.4 | 2.2 | ...... |
| 22 | 18.8 | 17.6 | 16.9 | 16.2 | 15.3 | 14.5 | 13.4 | 11.9 | 10.0 | 7.4 | 4.6 | 2.4 | ...... |
| 23 | 19.6 | 18.4 | 17.7 | 17.0 | 16.1 | 15.2 | 13.9 | 12.4 | 10.5 | 7.8 | 4.9 | 2.5 | ...... |
| 24 | 20.5 | 19.2 | 18.4 | 17.6 | 16.7 | 15.8 | 14.6 | 13.0 | 11.0 | 8.3 | 5.2 | 2.6 | ...... |
| 25 | 21.3 | 20.1 | 19.2 | 18.4 | 17.5 | 16.5 | 15.2 | 13.5 | 11.5 | 8.7 | 5.5 | 2.8 | ...... |
| 26 | 22.2 | 20.8 | 19.9 | 19.1 | 18.1 | 17.1 | 15.8 | 14.1 | 12.0 | 9.1 | 5.8 | 2.9 | ...... |
| 27 | 23.1 | 21.7 | 20.7 | 19.9 | 18.9 | 17.8 | 16.4 | 14.7 | 12.5 | 9.5 | 6.1 | 3.1 | ...... |
| 28 | 23.9 | 22.5 | 21.4 | 20.5 | 19.6 | 18.5 | 17.0 | 15.3 | 12.9 | 9.8 | 6.4 | 3.2 | ...... |
| 29 | 24.8 | 23.3 | 22.2 | 21.3 | 20.4 | 19.2 | 17.7 | 15.9 | 13.4 | 10.1 | 6.7 | 3.4 | ...... |
| 30 | 25.6 | 24.1 | 22.9 | 22.1 | 21.1 | 19.8 | 18.3 | 16.4 | 13.8 | 10.5 | 6.9 | 3.5 | ...... |
| 31 | 26.5 | 24.9 | 23.8 | 22.8 | 21.9 | 20.6 | 19.0 | 17.0 | 14.3 | 10.9 | 7.2 | 3.7 | ...... |
| 32 | 27.3 | 25.7 | 24.5 | 23.5 | 22.5 | 21.2 | 19.6 | 17.5 | 14.7 | 11.3 | 7.5 | 3.9 | ...... |
| 33 | 28.1 | 26.4 | 25.3 | 24.3 | 23.3 | 21.9 | 20.3 | 18.1 | 15.3 | 11.8 | 7.8 | 4.1 | ...... |
| 34 | 29.0 | 27.2 | 26.0 | 25.1 | 24.0 | 22.7 | 20.9 | 18.6 | 15.7 | 12.2 | 8.1 | 4.2 | ...... |
| 35 | 29.9 | 28.0 | 26.9 | 25.9 | 24.8 | 23.4 | 21.6 | 19.2 | 16.3 | 12.6 | 8.4 | 4.5 | ...... |
| 36 | 30.7 | 28.7 | 27.6 | 26.6 | 25.5 | 24.1 | 22.2 | 19.7 | 16.7 | 13.0 | 8.7 | 4.6 | ...... |
| 37 | 31.5 | 29.5 | 28.4 | 27.4 | 26.3 | 24.9 | 22.9 | 20.3 | 17.2 | 13.3 | 9.0 | 4.8 | ...... |
| 38 | 32.3 | 30.3 | 29.2 | 28.2 | 26.9 | 25.5 | 23.5 | 20.9 | 17.6 | 13.7 | 9.3 | 5.0 | ...... |
| 39 | 33.1 | 31.1 | 30.0 | 29.0 | 27.7 | 26.2 | 24.2 | 21.5 | 18.1 | 14.0 | 9.7 | 5.3 | ...... |
| 40 | 33.9 | 31.9 | 30.7 | 29.7 | 28.5 | 26.9 | 24.8 | 22.1 | 18.6 | 14.4 | 10.1 | 5.5 | ...... |
| 41 | 34.7 | 32.7 | 31.5 | 30.4 | 29.2 | 27.6 | 25.5 | 22.7 | 19.1 | 15.0 | 10.3 | 5.7 | ...... |
| 42 | 35.6 | 33.5 | 32.3 | 31.2 | 29.9 | 28.3 | 26.1 | 23.2 | 19.6 | 15.3 | 10.6 | 6.0 | ...... |
| 43 | 36.4 | 34.2 | 33.0 | 32.0 | 30.6 | 29.0 | 26.8 | 23.9 | 20.1 | 15.7 | 11.0 | 6.2 | ...... |
| 44 | 37.3 | 35.0 | 33.8 | 32.7 | 31.4 | 29.7 | 27.4 | 24.4 | 20.6 | 16.1 | 11.3 | 6.4 | ...... |
| 45 | 38.1 | 35.8 | 34.6 | 33.5 | 32.1 | 30.4 | 28.1 | 25.1 | 21.1 | 16.5 | 11.7 | 6.8 | ...... |
| | 120-foot trees. | | | | | | | | | | | | |
| 16 | 14.0 | 13.1 | 12.4 | 11.7 | 11.1 | 10.5 | 9.8 | 9.0 | 7.8 | 6.2 | 4.4 | 2.6 | 1.6 |
| 17 | 14.8 | 13.9 | 13.2 | 12.5 | 11.9 | 11.2 | 10.4 | 9.6 | 8.4 | 6.7 | 4.8 | 2.9 | 1.3 |
| 18 | 15.6 | 14.7 | 13.9 | 13.2 | 12.6 | 12.0 | 11.0 | 10.2 | 8.9 | 7.1 | 5.2 | 3.2 | 1.5 |
| 19 | 16.4 | 15.5 | 14.7 | 13.9 | 13.3 | 12.6 | 11.7 | 10.8 | 9.5 | 7.7 | 5.6 | 3.6 | 1.9 |
| 20 | 17.3 | 16.3 | 15.5 | 14.7 | 14.0 | 13.3 | 12.4 | 11.4 | 10.0 | 8.1 | 5.9 | 3.7 | 2.0 |
| 21 | 18.0 | 16.9 | 16.3 | 15.4 | 14.7 | 14.0 | 13.1 | 12.0 | 10.6 | 8.6 | 6.3 | 4.0 | 2.2 |
| 22 | 18.9 | 17.7 | 17.0 | 16.2 | 15.4 | 14.8 | 13.8 | 12.6 | 11.2 | 9.1 | 6.6 | 4.3 | 2.5 |
| 23 | 19.6 | 18.5 | 17.8 | 16.9 | 16.2 | 15.5 | 14.4 | 13.3 | 11.7 | 9.6 | 7.0 | 4.6 | 2.6 |
| 24 | 20.5 | 19.3 | 18.6 | 17.7 | 16.9 | 16.2 | 15.1 | 13.9 | 12.3 | 10.0 | 7.4 | 4.9 | 2.8 |
| 25 | 21.3 | 20.1 | 19.3 | 18.5 | 17.7 | 16.9 | 15.8 | 14.5 | 12.9 | 10.6 | 7.9 | 5.2 | 3.0 |
| 26 | 22.1 | 20.9 | 20.1 | 19.3 | 18.4 | 17.6 | 16.5 | 15.2 | 13.5 | 11.1 | 8.3 | 5.5 | 3.2 |
| 27 | 22.9 | 21.7 | 20.9 | 20.1 | 19.3 | 18.4 | 17.2 | 15.8 | 14.0 | 11.6 | 8.8 | 5.8 | 3.4 |
| 28 | 23.8 | 22.5 | 21.6 | 20.9 | 20.1 | 19.1 | 17.9 | 16.5 | 14.6 | 12.1 | 9.2 | 6.1 | 3.6 |
| 29 | 24.6 | 23.2 | 22.4 | 21.6 | 20.9 | 19.9 | 18.5 | 17.1 | 15.2 | 12.6 | 9.6 | 6.5 | 3.9 |
| 30 | 25.5 | 24.1 | 23.2 | 22.5 | 21.7 | 20.6 | 19.2 | 17.7 | 15.8 | 13.2 | 10.0 | 6.8 | 4.0 |
| 31 | 26.4 | 24.8 | 24.0 | 23.3 | 22.5 | 21.4 | 19.9 | 18.4 | 16.4 | 13.7 | 10.5 | 7.1 | 4.3 |
| 32 | 27.3 | 25.7 | 24.8 | 24.1 | 23.3 | 22.1 | 20.8 | 19.1 | 17.0 | 14.2 | 11.0 | 7.5 | 4.4 |
| 33 | 28.1 | 26.5 | 25.6 | 24.9 | 24.0 | 22.9 | 21.5 | 19.7 | 17.5 | 14.7 | 11.4 | 7.8 | 4.7 |
| 34 | 29.0 | 27.3 | 26.4 | 25.6 | 24.8 | 23.6 | 22.3 | 20.4 | 18.1 | 15.3 | 11.9 | 8.2 | 4.9 |
| 35 | 29.8 | 28.1 | 27.1 | 26.4 | 25.6 | 24.4 | 22.9 | 21.0 | 18.7 | 15.8 | 12.4 | 8.5 | 5.1 |
| 36 | 30.7 | 28.9 | 27.9 | 27.1 | 26.3 | 25.1 | 23.6 | 21.6 | 19.3 | 16.3 | 12.8 | 8.9 | 5.3 |
| 37 | 31.6 | 29.6 | 28.7 | 27.9 | 27.1 | 25.9 | 24.3 | 22.3 | 19.9 | 16.9 | 13.2 | 9.3 | 5.6 |
| 38 | 32.4 | 30.5 | 29.4 | 28.6 | 27.8 | 26.6 | 24.9 | 22.9 | 20.5 | 17.4 | 13.6 | 9.6 | 5.8 |
| 39 | 33.3 | 31.2 | 30.2 | 29.4 | 28.6 | 27.3 | 25.7 | 23.6 | 21.0 | 17.9 | 14.1 | 10.0 | 6.1 |
| 40 | 34.1 | 32.0 | 31.0 | 30.2 | 29.3 | 28.0 | 26.4 | 24.2 | 21.6 | 18.4 | 14.6 | 10.3 | 6.3 |
| 41 | 34.9 | 32.8 | 31.7 | 31.0 | 30.1 | 28.8 | 27.1 | 24.9 | 22.2 | 18.8 | 15.0 | 10.7 | 6.6 |
| 42 | 35.8 | 33.6 | 32.5 | 31.7 | 30.8 | 29.5 | 27.7 | 25.5 | 22.8 | 19.3 | 15.4 | 11.1 | 6.8 |
| 43 | 36.6 | 34.4 | 33.3 | 32.5 | 31.5 | 30.2 | 28.5 | 26.1 | 23.3 | 19.8 | 15.9 | 11.6 | 7.1 |
| 44 | 37.5 | 35.2 | 34.1 | 33.3 | 32.3 | 31.0 | 29.2 | 26.8 | 23.9 | 20.3 | 16.3 | 11.8 | 7.3 |
| 45 | 38.2 | 35.9 | 34.8 | 34.0 | 33.0 | 31.6 | 29.9 | 27.4 | 24.4 | 20.8 | 16.8 | 12.2 | 7.6 |
| 46 | 39.1 | 36.8 | 35.7 | 34.7 | 33.7 | 32.3 | 30.6 | 28.1 | 25.0 | 21.3 | 17.1 | 12.5 | 7.8 |
| 47 | 40.0 | 37.6 | 36.4 | 35.5 | 34.5 | 33.1 | 31.3 | 28.8 | 25.6 | 21.8 | 17.6 | 12.9 | 8.0 |

TABLE 22.—*Diameters inside bark at different heights above the ground for trees of different sizes, based on measurements of 1,548 trees in the Southern Appalachian region*—Con.

| Diameter breast-high outside bark. | 130-foot trees. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Height above ground—feet. | | | | | | | | | | | | | | |
| | 10.15 | 18.3 | 26.45 | 34.6 | 42.75 | 50.9 | 59.05 | 67.2 | 75.35 | 83.5 | 91.65 | 99.8 | 107.95 | 116.1 | 124.25 |
| | Diameter inside bark—inches. | | | | | | | | | | | | | | |
| *Inches.* | | | | | | | | | | | | | | | |
| 18 | 15.4 | 14.5 | 13.8 | 13.1 | 12.4 | 11.7 | 10.9 | 9.9 | 8.7 | 7.4 | 6.0 | 4.6 | 3.3 | 2.0 | ...... |
| 19 | 16.4 | 15.3 | 14.6 | 13.9 | 13.2 | 12.5 | 11.7 | 10.6 | 9.3 | 8.0 | 6.5 | 5.0 | 3.6 | 2.2 | ...... |
| 20 | 17.3 | 16.1 | 15.4 | 14.7 | 14.0 | 13.3 | 12.5 | 11.3 | 9.9 | 8.6 | 7.1 | 5.5 | 3.9 | 2.4 | ...... |
| 21 | 18.2 | 17.0 | 16.2 | 15.5 | 14.8 | 14.1 | 13.3 | 12.1 | 10.7 | 9.2 | 7.6 | 6.0 | 4.2 | 2.6 | ...... |
| 22 | 18.9 | 17.7 | 17.0 | 16.3 | 15.6 | 14.8 | 14.1 | 12.8 | 11.4 | 9.8 | 8.1 | 6.3 | 4.5 | 2.8 | ...... |
| 23 | 19.9 | 18.5 | 17.8 | 17.1 | 16.4 | 15.6 | 14.8 | 13.6 | 12.1 | 10.4 | 8.6 | 6.7 | 4.8 | 3.0 | ...... |
| 24 | 20.7 | 19.3 | 18.6 | 17.9 | 17.2 | 16.4 | 15.5 | 14.3 | 12.7 | 11.0 | 9.1 | 7.1 | 5.1 | 3.2 | ...... |
| 25 | 21.6 | 20.2 | 19.5 | 18.7 | 18.0 | 17.2 | 16.4 | 15.0 | 13.5 | 11.7 | 9.7 | 7.5 | 5.4 | 3.4 | ...... |
| 26 | 22.3 | 21.0 | 20.2 | 19.5 | 18.8 | 18.0 | 17.1 | 15.7 | 14.1 | 12.4 | 10.2 | 7.9 | 5.7 | 3.6 | ...... |
| 27 | 23.2 | 21.8 | 21.1 | 20.4 | 19.7 | 18.9 | 17.9 | 16.5 | 14.9 | 13.0 | 10.8 | 8.4 | 6.0 | 3.8 | ...... |
| 28 | 24.0 | 22.7 | 21.8 | 21.1 | 20.4 | 19.6 | 18.6 | 17.2 | 15.5 | 13.6 | 11.2 | 8.7 | 6.3 | 4.1 | ...... |
| 29 | 24.8 | 23.4 | 22.7 | 22.0 | 21.3 | 20.5 | 19.4 | 17.9 | 16.2 | 14.2 | 11.8 | 9.2 | 6.6 | 4.2 | ...... |
| 30 | 25.6 | 24.2 | 23.4 | 22.8 | 22.1 | 21.2 | 20.1 | 18.6 | 16.9 | 14.8 | 12.3 | 9.6 | 6.9 | 4.4 | ...... |
| 31 | 26.5 | 25.0 | 24.3 | 23.7 | 22.9 | 22.0 | 20.9 | 19.4 | 17.6 | 15.5 | 12.9 | 10.0 | 7.3 | 4.6 | ...... |
| 32 | 27.3 | 25.8 | 25.0 | 24.4 | 23.7 | 22.8 | 21.6 | 20.1 | 18.3 | 16.1 | 13.4 | 10.4 | 7.6 | 4.9 | ...... |
| 33 | 28.2 | 26.6 | 26.0 | 25.2 | 24.5 | 23.6 | 22.3 | 20.8 | 19.1 | 16.8 | 13.9 | 10.9 | 8.0 | 5.1 | ...... |
| 34 | 29.0 | 27.4 | 26.7 | 26.0 | 25.3 | 24.4 | 23.1 | 21.6 | 19.7 | 17.4 | 14.5 | 11.3 | 8.3 | 5.3 | ...... |
| 35 | 30.0 | 28.2 | 27.5 | 26.8 | 26.1 | 25.2 | 23.9 | 22.4 | 20.5 | 18.0 | 15.1 | 11.8 | 8.7 | 5.6 | ...... |
| 36 | 30.8 | 28.9 | 28.2 | 27.5 | 26.8 | 25.9 | 24.7 | 23.1 | 21.1 | 18.6 | 15.6 | 12.2 | 9.0 | 5.8 | ...... |
| 37 | 31.7 | 29.7 | 29.1 | 28.4 | 27.6 | 26.7 | 25.4 | 23.8 | 21.8 | 19.2 | 16.1 | 12.7 | 9.4 | 6.0 | ...... |
| 38 | 32.5 | 30.5 | 29.9 | 29.1 | 28.3 | 27.4 | 26.2 | 24.5 | 22.4 | 19.7 | 16.6 | 13.1 | 9.7 | 6.3 | ...... |
| 39 | 33.4 | 31.3 | 30.7 | 29.9 | 29.1 | 28.2 | 27.0 | 25.2 | 23.1 | 20.4 | 17.1 | 13.6 | 10.0 | 6.4 | ...... |
| 40 | 34.2 | 32.1 | 31.4 | 30.7 | 29.8 | 28.9 | 27.7 | 25.9 | 23.7 | 20.9 | 17.5 | 13.9 | 10.3 | 6.6 | ...... |
| 41 | 35.1 | 32.9 | 32.2 | 31.5 | 30.6 | 29.6 | 28.4 | 26.6 | 24.5 | 21.7 | 18.1 | 14.4 | 10.7 | 6.9 | ...... |
| 42 | 35.9 | 33.7 | 33.0 | 32.2 | 31.3 | 30.4 | 29.1 | 27.2 | 25.1 | 22.2 | 18.5 | 14.8 | 11.0 | 7.1 | ...... |
| 43 | 36.8 | 34.6 | 33.7 | 33.0 | 32.1 | 31.0 | 29.8 | 28.1 | 25.8 | 22.8 | 19.0 | 15.2 | 11.4 | 7.3 | ...... |
| 44 | 37.6 | 35.3 | 34.5 | 33.7 | 32.8 | 31.8 | 30.5 | 28.7 | 26.4 | 23.2 | 19.4 | 15.6 | 11.7 | 7.6 | ...... |
| 45 | 38.6 | 36.3 | 35.3 | 34.5 | 33.5 | 32.5 | 31.2 | 29.4 | 27.0 | 23.9 | 20.0 | 16.1 | 12.1 | 7.8 | ...... |
| 46 | 39.3 | 37.0 | 36.1 | 35.3 | 34.4 | 33.2 | 31.8 | 30.0 | 27.7 | 24.4 | 20.4 | 16.4 | 12.3 | 7.9 | ...... |
| 47 | 40.3 | 37.9 | 36.8 | 36.1 | 35.1 | 34.0 | 32.6 | 30.7 | 28.4 | 25.1 | 20.9 | 16.8 | 12.6 | 8.1 | ...... |
| | 140-foot trees. | | | | | | | | | | | | | | |
| 24 | 20.6 | 19.4 | 18.8 | 18.4 | 17.7 | 16.8 | 15.7 | 14.6 | 13.4 | 12.2 | 10.7 | 9.1 | 7.4 | 5.6 | 3.6 |
| 25 | 21.5 | 20.2 | 19.6 | 19.2 | 18.5 | 17.6 | 16.4 | 15.3 | 14.1 | 12.8 | 11.3 | 9.6 | 7.7 | 5.8 | 3.7 |
| 26 | 22.3 | 21.1 | 20.5 | 20.0 | 19.3 | 18.3 | 17.2 | 16.0 | 14.8 | 13.5 | 11.9 | 10.1 | 8.1 | 6.0 | 3.9 |
| 27 | 23.1 | 21.8 | 21.3 | 20.7 | 20.0 | 19.1 | 18.0 | 16.8 | 15.5 | 14.1 | 12.5 | 10.5 | 8.4 | 6.3 | 4.1 |
| 28 | 24.0 | 22.6 | 21.9 | 21.4 | 20.7 | 19.8 | 18.8 | 17.5 | 16.2 | 14.7 | 13.0 | 11.0 | 8.8 | 6.5 | 4.2 |
| 29 | 24.8 | 23.4 | 22.8 | 22.3 | 21.5 | 20.6 | 19.6 | 18.4 | 17.0 | 15.4 | 13.6 | 11.4 | 9.2 | 6.8 | 4.5 |
| 30 | 25.7 | 24.3 | 23.5 | 23.0 | 22.3 | 21.4 | 20.3 | 19.1 | 17.8 | 16.0 | 14.1 | 12.0 | 9.5 | 7.1 | 4.7 |
| 31 | 26.5 | 25.1 | 24.4 | 23.8 | 23.1 | 22.3 | 21.2 | 19.9 | 18.4 | 16.7 | 14.7 | 12.4 | 9.9 | 7.4 | 4.8 |
| 32 | 27.4 | 25.9 | 25.2 | 24.6 | 23.9 | 23.1 | 22.0 | 20.6 | 19.1 | 17.3 | 15.3 | 12.9 | 10.3 | 7.6 | 5.0 |
| 33 | 28.2 | 26.7 | 26.0 | 25.4 | 24.6 | 23.9 | 22.8 | 21.4 | 19.8 | 17.9 | 15.8 | 13.4 | 10.7 | 7.9 | 5.1 |
| 34 | 29.1 | 27.6 | 26.8 | 26.2 | 25.5 | 24.6 | 23.5 | 22.2 | 20.6 | 18.6 | 16.4 | 13.9 | 11.1 | 8.2 | 5.3 |
| 35 | 29.9 | 28.3 | 27.5 | 26.8 | 26.1 | 25.4 | 24.3 | 22.9 | 21.3 | 19.3 | 17.0 | 14.4 | 11.4 | 8.5 | 5.5 |
| 36 | 30.8 | 29.2 | 28.3 | 27.6 | 26.9 | 26.1 | 25.0 | 23.6 | 22.0 | 19.9 | 17.5 | 14.8 | 11.8 | 8.7 | 5.7 |
| 37 | 31.6 | 30.0 | 29.1 | 28.4 | 27.7 | 26.9 | 25.7 | 24.3 | 22.6 | 20.5 | 18.1 | 15.3 | 12.2 | 9.1 | 5.9 |
| 38 | 32.5 | 30.9 | 29.9 | 29.2 | 28.5 | 27.6 | 26.5 | 25.1 | 23.4 | 21.2 | 18.7 | 15.8 | 12.6 | 9.4 | 6.1 |
| 39 | 33.4 | 31.6 | 30.7 | 29.9 | 29.2 | 28.3 | 27.3 | 26.0 | 24.2 | 21.9 | 19.3 | 16.3 | 13.0 | 9.7 | 6.3 |
| 40 | 34.3 | 32.5 | 31.5 | 30.7 | 29.9 | 29.0 | 28.0 | 26.7 | 25.0 | 22.6 | 19.8 | 16.7 | 13.3 | 10.0 | 6.5 |
| 41 | 35.2 | 33.3 | 32.3 | 31.5 | 30.7 | 29.9 | 28.7 | 27.4 | 25.7 | 23.3 | 20.4 | 17.1 | 13.7 | 10.3 | 6.7 |
| 42 | 36.1 | 34.1 | 33.0 | 32.3 | 31.5 | 30.6 | 29.5 | 28.1 | 26.5 | 24.0 | 20.9 | 17.6 | 14.1 | 10.7 | 7.0 |
| 43 | 37.0 | 34.9 | 33.9 | 33.1 | 32.3 | 31.4 | 30.2 | 28.9 | 27.1 | 24.7 | 21.6 | 18.1 | 14.5 | 11.0 | 7.2 |
| 44 | 37.9 | 35.7 | 34.6 | 33.8 | 33.1 | 32.1 | 31.0 | 29.6 | 27.9 | 25.3 | 22.1 | 18.5 | 14.9 | 11.3 | 7.5 |
| 45 | 38.8 | 36.5 | 35.4 | 34.6 | 33.8 | 32.9 | 31.8 | 30.4 | 28.6 | 26.0 | 22.7 | 19.0 | 15.3 | 11.7 | 7.7 |
| 46 | 39.7 | 37.4 | 36.2 | 35.4 | 34.6 | 33.6 | 32.4 | 31.1 | 29.4 | 26.7 | 23.2 | 19.5 | 15.6 | 12.0 | 7.9 |
| 47 | 40.5 | 38.2 | 37.1 | 36.2 | 35.2 | 34.3 | 33.2 | 31.9 | 30.1 | 27.4 | 23.8 | 19.9 | 16.0 | 12.2 | 8.1 |
| 48 | 41.5 | 39.1 | 37.8 | 37.0 | 36.0 | 35.0 | 34.0 | 32.8 | 31.0 | 28.0 | 24.3 | 20.3 | 16.4 | 12.5 | 8.3 |
| 49 | 42.3 | 39.9 | 38.8 | 37.8 | 36.8 | 35.9 | 34.8 | 33.5 | 31.6 | 28.7 | 24.9 | 20.9 | 16.8 | 12.8 | 8.5 |
| 50 | 43.3 | 40.8 | 39.5 | 38.6 | 37.6 | 36.5 | 35.5 | 34.2 | 32.4 | 29.3 | 25.5 | 21.3 | 17.1 | 13.1 | 8.7 |

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